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Document de référence 2006/06

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TRAC

Transboundary Resource Assessment Committee

Reference Document 2006/06

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Assessment of Eastern Georges Bank Haddock for 2006

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2005 was 15,112 mt under a combined Canada/USA quota of 23,000 mt. The 2005 Canadian catch increased from 9,838 mt in 2004 to 14,542 mt while the USA catch decreased from 1,952 mt in 2004 to 569 mt. Estimated discards from the Canadian scallop fishery and USA groundfish fishery were very low relative to the total catch. EGB haddock catches fluctuated around 5,000 mt during 1985-1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass has steadily increased from near an historical low of about 9,000 mt in 1993 to about 74,000 mt in 2003. Adult biomass subsequently decreased to about 51,000 mt at the beginning of 2005 but increased to 123,000 mt in 2006, higher than the 1931-1955 maximum of about 90,000 mt. The 2003 year class, at 338 million age-1 fish, is estimated to be the largest ever observed in the assessment time series (1931-1955 and 1969-2006). The 2001, 2002 and 2004 year classes are weak but initial estimates of the 2005 year class suggest it is about average at 28 million fish. Fishing mortality (ages 4+) was below the reference threshold (F_{ref}) of 0.26 during 1995 to 2004. Fishing mortality in 2005 was slightly above F_{ref} due to the failure of the 2003 year class to contribute as expected to the 2005 fishery. The population age structure shows full representation of all age classes. However, resource productivity has diminished in recent years due to reductions in fish size at age.

With an assumed total catch of 22,000 mt in 2006, a combined Canada/USA catch of 19,000 mt in 2007 would result in a neutral risk (50%) that fishing mortality in 2007 would exceed F_{ref}=0.26. A catch of 16,000 mt would result in a low risk (25%) that fishing mortality in 2007 will exceed F_{ref}.

Slow growth of the 2003 cohort will continue to impact the fishery. If the TAC in 2006 is caught, fishing mortality in 2006 will be higher than F_{ref} on the fully recruited ages (F_{5+}=0.5).

RÉSUMÉ

En 2005, les prises totales d'aiglefin dans l'est du banc Georges se sont chiffrées à 15 112 tm, le quota combiné du Canada et des États-Unis étant de 23 000 tm. Les prises canadiennes ont augmenté, passant de 9 838 tm en 2004 à 14 542 tm en 2005, tandis que celles des États-Unis ont chuté de 1 952 tm à 569 tm pendant la même période. Les rejets estimés dans la pêche canadienne du pétoncle et la pêche du poisson de fond aux États-Unis étaient très faibles par rapport aux prises totales. Les prises d'aiglefin dans l'est du banc Georges ont fluctué alentour de 5 000 tm de 1985 à 1990. Suite à l'adoption de mesures de gestion restrictives, les prises combinées du Canada et des États-Unis ont diminué, passant de plus de 6 500 tm en 1991 à un seuil d'environ 2 100 tm en 1995, puis elles se sont situées en moyenne alentour de 3 600 tm de 1996 à 1999 et ont augmenté depuis.

La biomasse de la population adulte a constamment augmenté après être tombée à environ 9 000 tm, presque un seuil historique, en 1993 et elle s'est chiffrée à environ 74 000 tm en 2003. Elle a ensuite diminué à environ 51 000 tm au début de 2005, mais elle a augmenté au point d'atteindre 123 000 tm en 2006, ce qui est bien au-delà de la biomasse maximale de la période 1931-1955, soit environ 90 000 tm. On estime qu'avec ses 338 millions de poissons d'âge -1, la classe d'âge de 2003 est la plus grande observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2006). Les classes d'âge de 2001, 2002 et 2004 sont faibles, mais les estimations initiales de la classe d'âge de 2005 donnent à penser qu'elle se situe à peu près dans la moyenne, avec 28 millions de poissons. La mortalité par pêche (âges 4+) s'est située sous le seuil de référence ($F_{réf.}$) de 0,26 de 1995 à 2004. En 2005, elle a été légèrement supérieure à $F_{réf.}$ (F = 0,29), la classe d'âge de 2003 n'ayant pas contribué à la pêche de 2005 autant que prévu. Toutes les classes d'âge sont pleinement représentées dans la structure d'âges de la population. Toutefois, la productivité de la ressource a baissé ces dernières années en raison de la diminution de la taille moyenne du poisson selon l'âge.

Si on se fonde sur des prises hypothétiques totales de 22 000 tm en 2006, des prises combinées Canada-États-Unis de 19 000 tm en 2007 se traduiraient par un risque neutre (50 %) que la mortalité par pêche en 2007 soit supérieure à $F_{réf.}$ = 0,26. Des prises de 16 000 tm se traduiraient par un faible risque (25 %) que la mortalité par pêche en 2007 dépasse $F_{réf.}$

La lente croissance de la cohorte de 2003 continuera de se répercuter sur la pêche. Si le TAC de 2006 est capturé, la mortalité par pêche en 2006 sera supérieure à $F_{réf.}$ parmi les âges pleinement recrutés (F5+ = 0,5).

Introduction

For the purpose of developing a sharing proposal and consistent management by Canada and the USA, agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute and Brodziak (2005) to Canadian and USA fisheries information updated to 2005. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2006, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2006, and fall, updated to 2005, were incorporated.

Fishery

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982). Catches from eastern Georges Bank (EGB) during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s, ranging up to about 23,000 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, fluctuated between about 3,000 mt and 4,000 mt until 1999 and increased to 15,112 mt in 2005 (Table 1, Figure 3). In 2005, the Canadian catch was 14,542 mt and the USA catch was 569 mt under quotas of 15,410 mt for Canada and 7,590 mt for the USA.

Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Canadian catches since 1995 were below the quota due to closure of some fleet sectors when the cod quotas were reached, except for the year 2000 when the catch of 5,402 mt was slightly above the Canadian quota of 5,400 mt. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings in 2005 were monitored at dockside and at-sea observers monitored 16% by weight of the haddock landed in 2005. Discarding and misreporting of haddock by the groundfish fishery have been negligible since 1992.

Since 1994, the Canadian fishery for groundfish is usually not permitted from 1 January to 30 May. In 2005, an exploratory groundfish fishery was allowed due to increasing haddock abundance. So as not to adversely affect the rebuilding of cod on EGB , the exploratory winter fishery was closed in mid-February when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning

stages. In addition, 5 trips were made in May by otter trawlers under an exploratory license condition.

In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. During 2005, otter trawlers under 65 ft and fixed gear vessels 45-65 ft operated on individual quotas while fixed gear vessels under 45 ft operated on community quotas administered by local boards (Table 2). Vessels over 65 ft operate on Enterprise Allocations, which are company quotas. Smaller vessels are allowed to fish the quota which has been allocated to the larger vessels under the Temporary Vessel Replacement Program (TVRP) and increasing amounts of this quota have been taken by the TVRP boats in recent years. In 2005, 98% of the catch was taken by tonnage class 1, 2 and 3 (less than 150 tons) vessels (corresponding roughly to vessels less than 65 ft in overall length). Otter trawls took 84% of the haddock and longliners took 16% (Table 3). The highest catches in 2005 occurred during July and August (Table 4, Figure 4). The winter fishery accounted for 15% of the landings.

Canadian landings until 1995 include those catches reported by the scallop fishery but, since 1996, this fishery has been prohibited from landing haddock and this species was then discarded. Landed haddock by-catch, when landings were allowed, was low with a maximum of 38 mt reported in 1987 (Table 3). Discards of haddock by the Canadian scallop fishery (Table 1) were derived by Van Eeckhaute et al (2005). Discards of haddock for 1969 to 1995, when landings were still allowed, ranged between 69 and 186 mt. Discards of haddock for 1996 to 2004 ranged between 29 and 102 mt, lower than most values reported before 1996 due to lower effort in the scallop fishery. In 2005, discards of 52 mt were estimated (Van Eeckhaute and Gavaris 2006).

USA catches of EGB haddock in 2005 were derived from mandatory fishing vessel logbooks and dealer reports using the same procedures as for 1994-2004. Regulations for the USA fishery since 1994 have included increased trawl mesh sizes, large-scale closed areas, year-round and seasonal closed areas, days-at-sea limits for individual fishing vessels, daily catch limits and trip limits (Table 2). Haddock trip limits and daily catch limits were introduced in 1994 and 1996, respectively, to reduce fishing mortality. Low trip limits during the mid-1990s increased regulatory USA discards which were included in the USA catch at age for 1994-1998. Haddock trip limits were then increased to reduce discards and improve yield. In 2004 quota management was introduced to regulate the USA groundfish fishery (Table 2).

USA catches of EGB haddock declined substantially in 2005 (Table 1). Catches were low because the groundfish fishery on EGB was closed in August when the USA cod quota was reached. USA landings in 2005, under a catch quota of 7,590 mt, were 512 mt, a 71% decline from 2004 landings. USA discards declined from 156 mt in 2004 to 57 mt in 2005, a 63% decline, while total USA catch declined from 1,952 mt in 2004 to 569 mt in 2005. Quarterly USA landings in 2005 were: 40 mt (8%), 322 mt (63%), 149 mt (29%) and 1 mt (<1%) for calendar quarters 1 to 4 respectively (Table 5). Quarterly USA discards were: 5 mt (9%), 18 mt, (31%), 34 mt (60%) and <1 mt (<1%) for calendar quarters 1 to 4 respectively. Overall, the ratio of discarded to landed catch by weight for the USA EGB haddock fishery increased from 9% in 2004 to 11% in 2005.

The contribution of USA landings by other gear was higher in 2005 than previous years since 1994 (Table 6). Otter trawl gear accounted for 91% of the landings (465 mt) and 96% of the discards (55 mt). Hook and line gear accounted for 9% of the landings (47 mt) and 4% of the discards (2 mt). Gillnet gear accounted for less than 1% of the landings and discards. Overall, discards in the USA fishery have been relatively low in recent years due to high trip limits and larger trawl mesh size.

Size and Age Composition

The size and age composition of haddock in the 2005 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears and seasons. Comparison of port and at-sea length frequencies did not reveal any persistent differences (Figure 5), therefore, all data were combined (Table 7). The size composition of catch in the Canadian fisheries peaked at 52.5 cm (21 in) for otter trawlers and longliners (Figure 6). Gill-netters caught few haddock. The percentage of haddock below 43 cm was less than 1% in the Canadian groundfish fishery.

The size composition of haddock discards in the 2005 Canadian scallop fishery was characterized by quarter using length samples obtained from 11 observed scallop trips. Age composition was obtained by applying survey and groundfish fishery age-length keys to the quarterly length frequencies. Van Eeckhaute and Brodziak (2005) describe the methods used to characterize size and age composition in previous years. The annual Canadian scallop fishery haddock discards by age are presented in Table 8 and reflect a correction in calculation of the 2004 and earlier discards reported in the previous assessment (Van Eeckhaute and Brodziak 2005).

USA landings of EGB haddock are divided into large and scrod market categories for sale. Landings of large haddock totaled 83 mt in 2005, a 78% decrease from 2004 (Table 9). Landings of scrod also decreased from 1,421 mt in 2004 to 427 mt in 2005, a 70% decrease. The percentage of USA landings by weight of scrod haddock increased from 79% in 2004 to 84% in 2005. In general, the increase in the percentage of scrod landings reflects declines in haddock size at age on Georges Bank as well as the predominance of the 2000 year class in the catch.

Quarterly length samples from USA EGB landings in 2005 were used to characterize the length composition (Table 9). Because sampling intensity was relatively low in quarter 2 and also because no length samples were collected in quarter 4, the quarterly length frequency samples were augmented by length samples collected in adjacent areas (522 (5Zh) and 525 (5Zn)) that have similar size compositions compared to EGB. Landings peaked at 52 to 54 cm and discards peaked at 30 cm with another smaller mode at 48 cm (Figure 7).Quarterly samples of discards collected by at-sea observers were used to characterize the catch at length of the USA discards. Observer coverage increased from a total of 9% of USA haddock landings by weight from EGB in 2004 to 44% in 2005 (226 mt) during a total of 114 trips.

Quarterly age-length keys were applied to USA landings and discards at length to obtain catch at age. The quarter 1 USA fishery age-length key in 2005 was augmented with data from the DFO winter survey. Similarly, the USA fishery age-length keys in quarters 2 and 3 were augmented with NEFSC spring and autumn age-length data,

respectively, for lengths less than 40 cm to determine the catch at age of undersized discards.

Ages of survey and commercial-caught haddock were separately assigned by the DFO and the NMFS age readers, L. Van Eeckhaute and S. Sutherland, respectively. Intra-reader agreement tests for the DFO reader were not conducted for this assessment but testing conducted in the past indicated that age interpretations were internally consistent. NMFS testing was conducted on data from the NMFS 2005 fall and 2006 spring surveys, USA 2005 commercial landings by quarter and a haddock otolith reference collection (Sutherland et al. 2007). The tests involved a total of 483 otoliths. Agreement ranged between 92 and 97% for first and second readings indicating a high level of consistency in age determinations with no pattern of seasonal bias. Inter-reader testing between the NMFS reader and the DFO reader was not conducted for this assessment. However, inter-reader testing conducted for the previous assessment was very good at about 96% (Van Eeckhaute and Brodziak 2005). Age reader agreement was judged to be satisfactory for estimating catch at age.

The 2005 Canadian and USA landings and discards at age estimates by quarter (Table 10) were summed to obtain the quarterly and annual catch at age and appended to the 1969-2004 catch at age data (Van Eeckhaute and Brodziak 2005). Combined Canada/USA annual catch at age and average Canadian fishery weights and lengths at age are summarized in Tables 11, 12 and 13 and Figures 8 and 9. Canadian and USA fishery weights and lengths at age for 2005 are presented in Table 14. Canadian lengths and weights were generally higher than USA values, possibly reflecting seasonal differences in the catch. The 2000 year class (age 5), which contributed 77% of the catch by number, and the 1998 year class (age 7), at 9%, again dominated the fishery in 2005 (Figure 10). The exceptional 2003 year class had been projected to make up 32% in numbers of the total EGB catch but the actual catch of that year class was only 2% (Figure 11). The shortfall was due to the unanticipated slow somatic growth of that year class which resulted in a much lower partial recruitment to the fishery at age 2 than what was used in the previous assessment's projection. As a result, the 2000 year class made up a much higher percentage of the catch than anticipated, 77% instead of 45%. Age 5 haddock, the dominant age group for both countries (Table 10), account for 63% of USA landings compared to 78% of the Canadian landings, a difference of 15.7% (Table 10). USA discards represented 30% by numbers of the USA catch, 73% of which were age 2 haddock, but only 1% by numbers of the combined Can/USA catch. Overall, USA discard numbers decreased by 58% from 2004 totals. The dominant age group in the fishery has increased from age 2 and 3 during earlier periods to age 4 in recent years. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year classes which continued to contribute substantially at ages 6 and older (Figure 10).

Abundance Indices

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February) since 1986 and by NMFS each fall (October) since 1963 and each spring (April) since 1968.

All surveys use a stratified random design (Figures 12 and 13). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Vessel and door type conversion factors (Table 15), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent (Forrester et al 1997). Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock.

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for fall) in the most recent surveys is plotted to show the distribution in comparison to the average over the previous 10 year period (Figures 14, 15 and 16). The 2003 year class at age 2 in the NMFS 2005 fall survey was abundantly distributed on the northern edge, peak and southern flank. At age 3, the DFO and NMFS spring 2006 surveys found this year class abundantly and widely distributed throughout the bank. This year class was found in large quantities on the US side as well as the Canadian side, especially during the 2006 NMFS spring survey. The 2004 year class at age 1 was also distributed around the edges of the bank in fall but was found in highest concentrations on the Canadian side of the southern flank by the DFO survey the following spring, an atypical distribution for this age group which is usually found most abundantly on the northern edge at this time of year. This year class also occurred elsewhere throughout the EGB area but generally at lower densities. The NMFS spring survey found very low densities of this age group distributed throughout the bank. Some moderate catches of the 2005 year class were found by the fall survey (age 0) on the northern part of the bank. The DFO survey found a concentration of this year class at age 1 on the southern flank and some moderate catches on the northern edge, a typical distribution pattern for this age group at this time of year. They were similarly distributed during the NMFS spring survey.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year class strengths well (Tables 16, 17 and 18; Figure 17). Some year effects are evident. For example, low spring catches occurred in both the 1997 DFO and NMFS surveys. Survey biomass indices (ages 2-8 in fall; 3-8 in spring) peaked during the early 1960s (Figure 18). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Biomass generally increased during the 1990s. All three most recent surveys showed an increase in adult biomass (3+) from the previous year due to recruitment of the 2003 year class to the index.

All three survey series indicated that the 2003 year class is one of the strongest on record with good catches taken by the most recent surveys. Catches of the 2005 year class were higher than the 2004 year class for all 3 surveys. The 3 new survey observations for the 2004 year class support the view that it is somewhat stronger than the weak 2001 and 2002 year classes (Figure 19). The DFO spring and NMFS fall survey indices for the 2005 year class indicate it is a good year class although the NMFS spring survey is less optimistic.

The 2003 year class survey indices are the strongest in the time series, similar in abundance to the exceptional 1963 year class. The abundance of the 2000 year class is comparable to the strong 1975 and 1978 year classes.

Growth

Canadian fishery weights and lengths at age (Table 12 and 13, Figure 9) for ages 2 and 3 were generally higher during the mid-1990s than prior to the 1990s. This increase reflects a change in gear selectivity that occurred in the early 1990s. Canadian fishery weights in 2005 and DFO survey weights (Table 19 and Figure 9) and lengths (Table 20 and Figure 20) in 2006 declined or increased only slightly, continuing a downward trend that started after the mid-1990s for the older ages. Younger ages did not exhibit this declining trend until 2001. Average size at age has declined substantially so that haddock of age 2 and older are now at or smaller than the size that the next younger age group was in previous years before the declines occurred. Although survey adult biomass increased, the increase was not as great as expected, given the estimated magnitude of the 2003 year class. The slower growth of adult biomass was due to the marked reduction in growth of the recruiting 2003 year class.

Weights at age from the DFO survey are considered beginning of year population weights and are calculated using the method in Gavaris and Van Eeckhaute (1998) in which weights observed during the survey are weighted by population numbers at length and age. Fishery weights at age are derived from the sampled lengths at age and a length-weight relationship (Waiwood and Neilson 1985). In some cases, the mean weight at age in the catch was larger than the population mean weight at age at the beginning of the following year for the same cohort. This feature was mostly attributable to commercial fishery gear selectivity (Gavaris and Van Eeckhaute, 2000). However, some discrepancies in weights at age were more persistent and may be due to problems associated with the length-weight relationship and gutted-to-round weight conversion factors.

Harvest Strategy

The Transboundary Management Guidance Committee (TMGC 2003) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.26. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

Estimation of Stock Parameters

Calibration of Virtual Population Analysis (VPA)

Tuned virtual population analysis was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey data. An investigation of model formulations and model assumptions was conducted by Gavaris and Van Eeckhaute (1998). They provide details for the established model formulation and objective function used in this assessment. Based on this formulation it was assumed that observation errors for the catch at age data were negligible. Observation errors for the abundance indices were assumed to be independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M, was assumed constant and equal to 0.2. Similar model assumptions and methods were applied to the updated information

here. Minor differences in the handling of zero terminal catches for a year class were implemented as a refinement to the software to afford more flexibility. The population abundance for the 9+ age group was calculated but not calibrated to the indices. In the first quarter of the first year, the 9+ abundance calculation was based on the assumption that the fishing mortality for the 9+ age group was equal to the population weighted fishing mortality for ages 4 - 8. In the first quarter of subsequent years, the 9+ abundance was calculated as the sum of the age 8 and age group 9+ abundances at the end of the last quarter of the previous year.

The VPA was based on quarterly catch at age, $C_{a,t}$, for ages a = 0, 1, 2...8, 9+, and time t = 1969.0, 1969.25, 1969.5, 1969.75, 1970.0...2005.75 where t represents the beginning of the time interval during which the catch was taken. In previous assessments the catch at age contained no age 0 haddock since none were caught in the groundfish fishery. The inclusion of discards from the scallop fishery introduced age 0 fish into the catch at age. The effect of adding age 0s to the catch at age was determined to be negligible and since the discards were poorly estimated and values were low, age 0 catch was set to zero in the analysis. Ages 1 and older discards were included in the catch at age. The effect on the population estimate of adding older discards was minimal. The population was calculated to the beginning of 2006. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$, for

s = DFO, ages a = 1, 2, 3...8, time t = 1986.16, 1987.16... 2005.16, 2006.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3...8, time t = 1969.29, 1970.29, 1971.29, 1972.29, 1982.29, 1983.29...2005.29, 2006.00

s = NMFS spring (Yankee 41), ages a = 1, 2, 3...8, time t = 1973.29, 1974.29...1981.29

s = NMFS fall, ages a = 0, 1, 2...5, time t = 1969.69, 1970.69...2005.69

Since the population is calculated to beginning year 2006, the NMFS and DFO spring surveys in 2006 were designated as occurring at time 2006.00 The NMFS fall survey captures young of the year and that information is included as 0 group, but older haddock appear less available during this season. Survey indices for older ages where catches were sparse and where there were frequent occurrences of zero catches were not included (e.g., NMFS fall survey ages 6 and older and ages greater than 8 in the NMFS spring and the DFO surveys). Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. During years when discarding was high, survey information was used along with interviews to obtain estimates of the USA catch. This lack of complete independence between catch and survey data does not influence population estimates but may deflate variance estimates marginally.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at age 1 exhibited a large relative error of about 60% and a large relative bias of 16%, while the relative error for other ages was between 27% and 43% with a relative bias between 3% and 8% (Table 21). The relative bias on fishing mortality for ages 4 and older in 2005 was small at about 3%. While trends in the three surveys are generally consistent, the survey indices

exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a substantial impact on estimates of current abundance (Figures 21-25). Some patterns in the residuals (by cohort and by age) suggest year class and/or year effects.

Retrospective Analysis

Retrospective analyses were used to detect any patterns to consistently overestimate or underestimate fishing mortality, biomass and recruitment relative to the terminal year estimates. This stock assessment does not display a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998, 2000 and 2003 year classes, successive estimates of year class abundance at age do not display any persistent tendency to be higher or lower (Figure 26). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 27).

State of Resource

The state of the resource was based on results from an age structured analytical assessment (VPA) that used fishery catch statistics and sampling for size and age composition of the catch for 1969 to 2005 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series; NMFS spring, NMFS fall and DFO. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 21, 22 and 23). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 19) were used to calculate beginning of year population biomass (Table 24). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-85. Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm during 1931 to 1955 were used to reconstruct a population analysis of EGB that was suitable for comparison of productivity.

Population biomass (ages 3+) increased to 39,000 mt during the late 1970s and early 1980s due to recruitment of the strong 1975 and 1978 year classes whose abundances were estimated to be above 50 million age-1 fish each (Figure 28). However, biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two cohorts were fished intensely at young ages. Improved recruitment in the 1990s and the strong 2000 year class, lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near an historical low of 8,600 mt in 1993 to 73,800 mt in 2003. Adult biomass subsequently decreased to 51,000 mt in 2005 but increased in 2006 to 123,000 mt (80% Confidence Interval: 93,300 mt – 167,300 mt), higher than the 1931-1955 maximum biomass of about 90,000 mt. The marked increase in 2006 is due to the exceptional 2003 year class, estimated at 88,000 mt at age-3. Older ages sustained the fishery in 2005 and the strong 2000 year class is expected to continue to contribute substantially to the catch weight in 2006.

Recruitment improved in the 1990s and the exceptional 2003 year class, estimated at 338 million age-1 fish, is the largest in the assessment time series (1931-1955 and 1969-2005). The 2000 year class (72 million at age 1) is estimated to be larger than the strong 1975 and 1978 year classes (Figure 28). In contrast, the 2001, 2002 and 2004 year classes are weak, at about 4, 2 and 9 million fish respectively. Initial estimates of the 2005 year class (28 million age-1 fish) suggest that it is about average.

Fishing mortality for ages 4+ fluctuated between 0.2 and 0.4 during the 1980s (Figure 29) and markedly increased between 1989 and 1993 to about 0.6, the highest observed. Since 1995, fishing mortality has been below the reference, F_{ref} = 0.26, but increased in 2005 to slightly above F_{ref} (F_{2005} = 0.29; 80% Confidence Interval: 0.23 – 0.37). However, the age at which haddock are fully recruited to the fishery has increased and fishing mortality based on these ages, 5+, has been higher than F for ages 4+ since 2003 and in 2004 was also slightly above F_{ref}.

The significant reduction in weights at age and the decline in condition are reflected in a reduction in partial recruitment to the fishery. The average partial recruitment for 2004 and 2005 shows a decrease from the 2002 to 2004 average for ages 3 and 4 (Table 25 and Figure 30). The partial recruitment values used to project the 2005 catch (Van Eeckhaute and Brodziak 2004) were normalized on ages 4-8. Lower weights at age have resulted in a reduced partial recruitment so that age 4 is now no longer fully recruited to the fishery. Partial recruitment estimate for ages 1 to 4 for recent years are more appropriately normalized on ages 5-8 (Table 26). Due to the magnitude of the 2003 year class, the partial recruitment pattern used for this year class will have a significant impact on estimates of the magnitude and composition of future catches.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock, which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Except for 1996, 2001, 2003 and 2004 surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) since 1993 has exceeded fishery harvest yields, resulting in net population biomass increases (Figure 31). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year classes enter the population, e.g. the 2000 year class in 2002 and the 2003 year class in 2005 (Figure 32). The biomass contributed by the 2003 year class, both when it recruited at age 2 and through growth during that year was greater than that of any other previous cohort since 1969.

Productivity

Stock characteristics such as recruits per spawner, age structure, spatial distribution and fish growth reflect changes in the productive potential.

Stock-recruitment data indicates that the chance of a good year class is significantly enhanced for adult biomass above about 40,000 mt (Figure 33). Since 1969, only the 1975, 1978, 2000 and 2003 year classes have been above the average abundance of

year classes observed during the period 1931-55. The recruits per adult biomass ratio was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 34). The recruits per adult biomass ratio suggests that higher recruitment might occur when the biomass is above 40,000 mt. However, in the early 2000's, excepting 2000 and 2003, which have among the highest ratios seen since 1931, recruits per spawner for three of those years were again low.

A broad representation of age groups is apparent, in both absolute number and percent composition, reflecting improved recruitment and lower exploitation, particularly at younger ages, since 1995 (Figure 35).

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years. However, consistent with the pattern observed for previous large year classes, the exceptional 2003 year class, the main component of the 3+ age group, was widely distributed throughout the survey area (Figures 14, 15 and 16).

DFO survey average weights at length, used to reflect condition, show a decrease for smaller haddock (48 to 53 cm) during the last 3 years and a longer trend is evident for larger fish (68 to 73 cm). For these lengths, weights are at their lowest values in the DFO survey time series (Figure 36). The percent change in weight at length indicates a decline in condition for most lengths during the years 2000 and 2004 and from the year 2000 to the beginning of 2006 there is a decline in condition for all except one length grouping (Figure 37). Reduced growth is also evident in the rate of change in DFO survey lengths at age (Table 27 and Figure 38) and is particularly evident in 2001 and 2004.

In summary, productivity increased since the 1980s due to improved recruits per spawner and increases in the number of larger and older fish in the population, however, productivity has severely diminished in recent years due to reductions in fish size at age and condition.

Outlook

This outlook shows the effects of alternative catch quotas on the risk of exceeding the fishing mortality reference level in 2007. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding F_{ref}=0.26. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough.

The 2003 year class will comprise a large portion of the 2007 catch. Predictions of weights at age and partial recruitment for this year class used for input into the risk assessment are very influential for catch projections. A scatterplot of the observed instantaneous growth rates, calculated as $growth\ rate=ln(L_{a+1})-ln(L_a)$, for the 1998, 1999 and 2000 year classes suggests that growth rate diminishes with length (Figure 39).

Only these year classes were used to characterize the growth of the 2003 year class because the growth rates of earlier year classes was higher. Applying a parsimonious linear functional form, the relationship between growth rate and length was approximated as *growth rate = 0.484 - 0.00889 x length*. The predicted growth rate at length was applied to the 2006 DFO survey average length for the 2003 year class (34 cm at age 3) to obtain the beginning of year length at age 4, i.e. $L_4=L_3 \times e^{growth\ rate}$, and then sequentially, at age 5 using the growth rate predicted for the length at age 4, etc (Table 28). Average fishery lengths were determined by interpolating between beginning of year lengths using the observed patterns from nearby year classes (Figure 40). The length estimates were then converted to weights using the length weight relationship used to convert the Canadian fishery lengths to weights and were reduced by 10% to account for the observed reduction in fish condition in recent years (Table 29).

Recent observed (2003 to 2005) partial recruitment values were compared to beginning year (survey) lengths (Figure 41) to help determine partial recruitment values for the 2003 yearclass. A value of 0.3 which is about 10% less than the partial recruitment for age 4 in 2005 was judged to be appropriate for the 2003 year class at age 4. This value is also lower than the recent 3 year average for this age group, which is appropriate since lengths and weights at age were higher at that time. The 2005 observed fishery weights and partial recruitment were used for year classes preceding and following the 2003 year class except for the weight for age 1, which, in 2005, was derived from only one observation. The 2001 age 1 (2000 year class) fishery weight, the lowest observed value from the most recent five years, was used for age 1 to reflect the decline in growth.

A risk assessment was conducted to beginning year 2008 based on these patterns in growth and partial recruitment. Stock size estimates at the beginning of 2006 were used to start the forecasts. Abundances of the 2006 and 2007 year classes were assumed to be 20 million at age 1. Natural mortality was assumed to be 0.2 (Table 30).

Assuming a 2006 catch equal to the 22,000 mt total quota, a combined Canada/USA catch of 19,000 mt in 2007 would result in a neutral risk (50%) that the fishing mortality rate in 2007 will exceed F_{ref} = 0.26 (Figure 42). A catch of 16,000 mt would result in a low risk (25%) that the fishing mortality rate in 2007 will exceed F_{ref}. Adult biomass is projected to be 149,000 mt in 2007 and will increase by less than 10% in 2008. The 2003 year class (age 4) will comprise the highest proportion of the total 2007 yield accounting for 72% of the catch at the 19,000 mt level (81% by numbers). The 2000 year class will account for the second highest proportion (17% of the catch biomass and 11% by numbers) (Table 31).

Medium term projections were not conducted due to uncertainties in future growth trends of the 2003 year class and this cohort's overwhelming influence on future adult biiomass.

Special Considerations

The outstanding 2003 year class was expected to contribute substantially (32%) to the 2005 catch. However, the contribution was negligible (2%) due to a failure to recruit to the fishery because of slow growth. The failure of this year class to contribute as expected to the fishery resulted in fishing mortality above F_{ref} on the older ages in 2005. This has been exacerbated by the two weak year classes preceding the 2003 year class. Slow growth of the 2003 cohort will continue to impact the fishery. If the TAC in 2006 is caught, fishing mortality will be higher than F_{ref} on the fully recruited ages (F_{5+}=0.5). Due to the high abundance of the 2003 cohort and its slow growth, discards of this year class may be high and should be monitored.

While best judgement was used to determine the weights at age and fishery partial recruitments for the projections, the risk analysis may not capture the full extent of uncertainty of the consequences for various catch levels, which are important in this instance and should be used in a precautionary manner.

Acknowledgements

G. Donaldson, E. Williams, J. Fennel and Javitech Ltd. provided samples from the Canadian fishery. We thank members of the fishing industry who spent time to discuss their experiences in the fishery. We also thank Stratis Gavaris and Ralph Mayo for providing valuable comments on the draft manuscript.

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Table 1. Nominal catches (mt) of haddock from EGB during 1969-2005. For "Other" it was assumed that 40% of the total 5Z catch was in EGB.

	Landings			Discards		Total	Quotas	
Year	Canada	USA	Other	Canada	USA	Catch	Canadian	USA
1969	3941	6622	695	123		11258		
1970	1970	3153	357	116		5480		
1971	1610	3534	770	111		5914		
1972	609	1551	502	133		2795		
1973	1565	1396	396	98		3455		
1974	462	955	573	160	757	2907		
1975	1353	1705	29	186		3273		
1976	1355	973	24	160		2512		
1977	2871	2429		151	2966	8417		
1978	9968	4724		177	1556	16425		
1979	5080	5211		186		10477		
1980	10017	5615		151	7561	23344		
1981	5658	9077		177		14912		
1982	4872	6280		130		11282		
1983	3208	4454		119		7781		
1984	1463	5121		124		6708		
1985	3484	1683		186		5353		
1986	3415	2200		92		5707		
1987	4703	1418		138		6259		
1988	4046	1693		151		5890		
1989	3060	787		138		3985		
1990	3340	1189		128		4657		
1991	5456	949		117		6522		
1992	4058	1629		130		5817	5000	
1993	3727	421		114		4262	5000	
1994	2411	33		114	258	2816	3000	
1995	2065	22		69	25	2181	2500	
1996	3663	36		52	41	3792	4500	
1997	2749	48		60	63	2919	3200	
1998	3371	311		102	14	3798	3900	
1999	3681	355		49		4084	3900	
2000	5402	187		29		5618	5400	
2001	6774	604		39	40	7417	6989	
2002	6488	914		29	35	7431	6740	
2003	6775	1564		98	63	8437	6933	
2004	9745	1796		93	156	11790	9900	5100
2005	14490	512		52	57	15112	15410	7590

[1] 1895 mt excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and EGB fishery management units by the USA and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
1984 Oct.	Implementation of the 'Hague' line .	
1985	5 ½" mesh size, Areas 1 and 2 closed February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		EGB adopted as management unit. For MG < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of ITQs and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from Jan 1-June30.	OT fishery permitted to operate in Jan. and Feb. Increase in use square mesh. TAC = 5000 mt.
1994	Jan.: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishng until July 1. Predominantly square mesh by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh. Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock pollock, hake or cusk combined can participate in 5Z fishery. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt. Restrictions on catching of cod and haddock under 43 cm (small fish protocol).
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
1997	May: Additional scheduled Days-at-sea restrictions.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on

	USA	Canada
	September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3200 mt.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3900 mt.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	TAC = 3,900 mt.; mandatory cod separator panel when no observer on board;
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in Oct. 2003.	TAC = 6,933 mt for 2003.
Canada - USA Resource Sharing Agreement on Georges Bank		
2004	May 1, day and trip limits removed. TAC = 5,100 mt. Oct. 1: unit areas 561 and 562 closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC= 7,590 mt. Jan. 14: cod separator trawl required.	TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 18, 2005.

Table 3. Canadian landings (mt) of haddock from EGB during 1969-2005 by gear category and tonnage class for principal gears.

Year	Otter Trawl						Longline			Scallop Fishery	Other	Total
	Side	Stern										
		2	3	4	5	Total[1]	2	3	Total[1]			
1969	777	0	1	225	2902	3127	2	21	23	15	0	3941
1970	575	2	0	133	1179	1314	6	72	78	2	1	1970
1971	501	0	0	16	939	955	18	129	151	3	0	1610
1972	148	0	0	2	260	263	23	169	195	1	2	609
1973	633	0	0	60	766	826	23	80	105	0	1	1565
1974	27	0	6	8	332	346	29	59	88	1	0	462
1975	222	0	1	60	963	1024	25	81	107	0	0	1353
1976	217	0	2	59	905	967	48	108	156	0	15	1355
1977	370	92	243	18	2025	2378	43	51	94	1	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	17	287	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	0	5080
1980	1444	354	359	950	6254	7917	129	51	587	4	65	10017
1981	478	448	629	737	2344	4159	331	99	1019	1	1	5658
1982	115	189	318	187	3341	4045	497	187	712	0	0	4872
1983	106	615	431	107	1130	2283	593	195	815	1	3	3208
1984	5	180	269	21	149	620	614	192	835	2	1	1463
1985	72	840	1401	155	348	2745	562	33	626	2	39	3484
1986	51	829	1378	95	432	2734	475	98	594	4	32	3415
1987	48	782	1448	49	1241	3521	854	113	1046	38	50	4703
1988[2]	72	1091	1456	186	398	3183	428	200	695	16	80	4046
1989	0	489	573	376	536	1976	713	175	977	12	95	3060
1990	0	928	890	116	471	2411	623	173	853	7	69	3340
1991	0	1610	1647	81	689	4028	900	271	1309	8	111	5456
1992	0	797	1084	56	645	2583	984	245	1384	4	87	4058
1993	0	535	1179	67	699	2489	794	156	1143	2	93	3727
1994	0	495	911	79	112	1597	498	47	714	9	91	2411
1995	0	523	896	14	214	1647	256	75	390	7	21	2065
1996	1	836	1405	166	270	2689	561	107	947	0	26	3663
1997	0	680	1123	91	96	1991	501	116	722	0	36	2749
1998	0	863	1340	98	71	2422	570	252	921	0	28	3371
1999	0	954	1471	174	145	2761	486	241	887	0	32	3680
2000	0	1313	2269	230	246	4146	619	258	1186	0	70	5402
2001	0	1564	2555	0	757	5112	754	302	1633	0	29	6774
2002	0	1217	2720	0	657	4954	794	151	1521	0	12	6488
2003	0	1186	3246	0	0	4985	806	249	1776	0	14	6775
2004	0	2152	4651	0	67	7744	716	223	2000	0	1	9745
2005	0	2929	7393	326	0	12115	706	78	2375	0	0	14490

[1] Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

[2] Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

Table 4. Monthly landings (mt) of haddock by Canada from EGB during 1969-2005.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988[1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1703	983	1364	820	593	452	6488
2003	0	0	0	0	0	840	1767	1290	930	952	676	320	6775
2004	0	0	0	0	0	1547	2268	2109	1753	1275	556	236	9745
2005	1025	1182	0	0	13	1423	3006	3820	2203	1198	357	266	14490

[1] Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. Monthly landings (mt) of haddock by the USA from EGB during 1969-2005. Details for 1994-2005 are not available because data are preliminary.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	281	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421
1994													33
1995													22
1996													36
1997													48
1998													311
1999													355
2000													187
2001													604
2002													914
2003													1564
2004[1]		266			1196			307			27		1796
2005[1,2]		40			322			149			1		512

[1]Landings by quarter.
[2]Fishery was closed in August when cod by-catch quota reached.

Table 6. USA landings (mt) of haddock from EGB during 1969-2005 by gear category and tonnage class. Details for 1994-2005 are not available because data are preliminary.

Year	Otter Trawl			Other	Total
	3	4	Total		
1969	3010	3610	6621	0	6622
1970	1602	1551	3154	0	3153
1971	1760	1768	3533	0	3534
1972	861	690	1551	0	1551
1973	637	759	1396	0	1396
1974	443	512	955	0	955
1975	993	675	1668	36	1705
1976	671	302	972	2	973
1977	1721	700	2423	5	2429
1978	3140	1573	4713	11	4724
1979	3281	1927	5208	4	5211
1980	3654	2955	5611	4	5615
1981	3591	5408	9031	45	9077
1982	2585	3657	6242	37	6280
1983	1162	3261	4423	29	4454
1984	1854	3260	5115	5	5121
1985	856	823	1679	4	1683
1986	985	1207	2192	9	2200
1987	778	639	1417	1	1418
1988	920	768	1688	6	1693
1989	359	419	780	6	787
1990	486	688	1178	4	1189
1991	400	517	918	13	931
1992	597	740	1337	292	1629
1993	142	191	333	88	421
1994			32	0	33
1995			21	0	22
1996			36	0	36
1997			48	0	48
1998			311	0	311
1999			355	0	355
2000			187	0	187
2001			602	2	604
2002			913	1	914
2003			1564	0	1564
2004			1794	2	1796
2005			465	47	512

Table 7. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2005 from EGB.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages
				At Sea		Port		
				Trips	Measured	Samples	Measured	
1	OT<65	Jan	1,019,348	4	1,210	5	928	Survey = 1,171
		Feb	1,181,622	8	1,049	3	685	Port = 26
	LL<65	Jan	5,713					Estimated = 4
	DR[1]		10,934	3	474			Total = 1201
2	OT<65	May	12,521					
		June	1,329,149	21	15,781	9	1856	At Sea = 194
	OT >65	June	47,963	2	2,001			Port = 201
	LL <65	June	45,520	1	127	2	450	Estimated = 7
	GN<65	June	88					Total = 402
	DR[1]		5,755	2[2]	191[2]			
3	OT <65	July	2,646,157	28	15,050	8	1680	
		Aug	2,696,768	14	6,457	7	1670	
		Sept	1,531,412	1	482	5	874	
	OT >65	Jul	49,012	2	1,306			
		Aug	100,433					At Sea = 115
		Sept	36,271					Port = 411
	LL <65	July	310,445	5	3,367	2	396	Estimated = 12
		Aug	1,022,408	12	11,104	6	1435	Total = 538
		Sept	635,373	3	660	3	1540	
	GN <65	July	243					
		Sept	80					
	DR[1]		20,298	4	981			
4	OT <65	Oct	801,595	3	2,801	6	1496	
		Nov	323,008	1	2,377	1	490	
		Dec	247,849	2	1,786	3	705	
	OT>65	Oct	64,835					
		Nov	10,542	1	137			At Sea = 19
		Dec	16,524					Port = 224
	LL <65	Oct	331,222	1	681	2	435	Estimated = 26
		Nov	23,094	1	619	1	175	Total = 269
		Dec	1,184					
	GN <65	Oct	48					
	DR[1]		15,506	3	349			
Totals			14,490,478	122	68,990	63	14,815	2,410

OT=Otter Trawl Bottom, GN=Gill Net, LL=Longline, DR=Scallop Dredge, <65=Less than 65' overall length, >65=Greater than 65' overall length.

[1]Discards from the scallop fishery were estimated by quarter.

[2]Augmented with one July sample (145 measured).

Table 8. Revised[1] annual Canadian scallop fishery numbers of discards at age of haddock from EGB during 1968-2005. The age compositions for 1968 to 2003 and 2004 in quarters 1 and 2 were determined using survey data. The age compositions for 2004 in quarters 3 and 4 and for 2005 were derived using length samples from the scallop fishery.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
1968	494	1023	18888	492	2768	37455	12263	2453	840	3264	79940
1969	5635	67	135	10426	1895	2499	24194	11892	1894	3089	61727
1970	0	41524	2597	103	4027	4643	4263	13682	8699	3180	82718
1971	42997	0	19315	4145	0	5746	1442	1764	18021	5673	99102
1972	117647	86946	0	13932	1399	269	1814	2242	282	19725	244256
1973	6677	103487	35717	0	5852	736	0	1366	0	5871	159706
1974	9093	20096	152048	28838	0	1972	0	196	331	5666	218240
1975	552921	17124	8900	76268	14473	0	2074	1208	432	2490	675891
1976	1101	328833	7845	7625	20916	9646	0	26	0	443	376435
1977	155	1301	192529	2536	4103	3659	2577	12	100	412	207383
1978	109719	4098	6378	125375	2502	3169	4473	289	76	376	256454
1979	12084	212346	2166	8658	56811	2557	423	2077	196	41	297357
1980	30501	29828	140223	1505	2342	17090	1756	722	974	488	225429
1981	6138	54507	32609	85831	7088	2999	8485	736	119	195	198706
1982	569	1898	18211	9661	48383	3897	2369	7109	262	120	92478
1983	74629	10672	9705	14653	8228	24516	545	247	6778	361	150335
1984	764	72015	23157	10389	8897	5989	11766	820	454	3714	137965
1985	353386	8589	83877	11608	5990	9329	4375	10454	609	2934	491149
1986	286	83347	1642	28729	2336	1034	1649	1081	1674	1089	122864
1987	19469	443	90538	4610	20907	3811	1961	1326	1332	2986	147384
1988	868	48549	1698	53850	3042	17266	2358	2436	706	1913	132687
1989	7869	2227	116929	6986	22633	2764	6045	328	428	949	167158
1990	18440	29378	859	69120	2331	12176	966	2277	196	531	136273
1991	35349	16172	25223	2769	39414	1609	3789	291	902	376	125895
1992	150919	42787	18943	12353	977	18440	128	4331	726	1694	251297
1993	4446	73676	36597	7468	3200	1697	10139	678	1525	917	140344
1994	13494	32649	62697	24747	4679	2042	322	3161	101	899	144791
1995	4377	6591	23097	20155	6313	1099	561	52	1217	1084	64547
1996	6210	3670	4801	14864	10046	4634	442	254	31	965	45916
1997	698	27618	21398	4399	7030	5406	2318	231	195	522	69815
1998	18774	18065	34832	12757	6744	7869	7528	1713	269	537	109088
1999	1580	26031	8509	14370	3754	3994	2493	2401	1074	405	64610
2000	1025	5870	9636	5356	3231	946	514	757	387	262	27985
2001	456	19700	2489	10624	3744	3218	989	651	782	870	43523
2002	40	727	24393	4276	4083	1103	743	278	189	447	36277
2003	485703	634	1558	38188	3951	7293	1149	944	313	1024	540758
2004	304	82967	1608	2065	45363	3930	6721	1624	974	820	146375
2005	0	1496	25526	514	1010	18646	1784	2485	435	358	52254

[1]Revised from previous assessment.

Table 9. USA landings of haddock in 2005 by quarter and market category from EGB and NMFS sampling intensity for lengths and ages.

Market Category	Large	Scrod	Unclassified	Total
		Landings (mt)		
Quarter 1	11	29	1	40
Quarter 2	41	281	1	322
Quarter 3	31	117		149
Quarter 4	1	1		1
Total	83	427	2	512
		Length per 100 mt (Number measured)		
Quarter 1	276 (29)	161 (46)	N/A	436 (75)
Quarter 2	57 (23)	83 (234)	N/A	140 (257)
Quarter 3	739 (231)	85 (100)	N/A	824 (331)
Quarter 4	0 (0)	0 (0)	N/A	0 (0)
Total	1071 (283)	329 (380)	N/A	1400 (663)
		Age per 100 mt (Number aged)		
Quarter 1	238 (25)	52 (15)	N/A	290 (40)
Quarter 2	0 (0)	20 (55)	N/A	20 (55)
Quarter 3	272 (85)	43 (50)	N/A	314 (135)
Quarter 4	0 (0)	0 (0)	N/A	0 (0)
Total	510 (110)	114 (120)	N/A	624 (230)

Table 10. Components of the 2005 catch at age in numbers of haddock from EGB by quarter.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
Canadian Landings											
2004	0	0	159	1093	20000	788670	121940	201031	50029	39121	1222043
2004.25	0	3	2348	5641	32393	539933	88246	158895	20290	22450	870201
2004.5	0	0	69692	18290	148641	4368695	198720	307113	40846	75807	5227804
2004.75	0	0	14832	2239	12188	896889	81827	63914	6048	3651	1081588
Year total	0	3	87031	27263	213223	6594187	490734	730953	117214	141029	8401636
USA Landings											
2004	0	0	0	0	200	12600	2500	5000	1100	1700	23300
2004.25	0	0	0	200	4400	118700	17800	55400	5600	8600	210800
2004.5	0	0	0	100	1200	70900	4400	7500	1300	1800	87300
2004.75	0	0	0	0	400	100	200	0	0	0	800
Year total	0	0	0	300	6200	202300	24900	67900	8000	12100	322200
Canadian Discards											
2004	0	0	124	54	222	4433	639	978	218	125	6794
2004.25	0	0	2120	45	198	1976	357	499	60	77	5332
2004.5	0	45	15079	206	455	7053	276	450	113	113	23788
2004.75	0	1452	8202	209	135	5185	513	558	44	43	16340
Year total	0	1496	25526	514	1010	18646	1784	2485	435	358	52254
USA Discards											
2004	0	569	6677	147	298	2565	316	289	73	10	10944
2004.25	0	216	21082	273	778	7768	1225	2026	161	170	33700
2004.5	0	8578	70804	130	451	9455	243	364	48	141	90216
2004.75	0	3	19	0	2	0	0	0	0	0	25
Year total	0	9366	98583	549	1530	19789	1784	2680	282	321	134884
Total											
2004	0	569	6961	1293	20721	808268	125395	207298	51420	40956	1263081
2004.25	0	220	25550	6158	37770	668377	107628	216821	26111	31297	1120033
2004.5	0	8623	155576	18726	150747	4456103	203639	315427	42307	77861	5429108
2004.75	0	1455	23053	2448	12725	902174	82540	64471	6092	3694	1098753
Year total	0	10865	211139	28626	221963	6834922	519202	804018	125931	153808	8910975

Table 11. Total annual commercial catch at age numbers (000's) of haddock from EGB during 1969-2005. Estimates of discards are included.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
1969	6	0	18	1451	262	334	2909	831	91	283	6184
1970	0	66	84	7	351	151	130	1153	372	193	2508
1971	43	0	1201	251	31	252	159	161	774	412	3284
1972	118	346	1	390	72	21	94	39	16	451	1547
1973	7	1119	1758	6	364	38	10	39	8	169	3517
1974	9	37	2257	276	0	32	3	0	29	63	2706
1975	553	18	279	1504	216	5	36	2	2	31	2645
1976	1	402	157	173	834	135	0	19	0	18	1739
1977	0	1	8028	66	182	307	164	0	15	15	8778
1978	110	6	291	9956	164	173	306	80	10	9	11105
1979	12	212	17	208	4307	364	201	217	43	14	5597
1980	31	32	17701	343	302	2425	193	130	52	12	21220
1981	6	55	693	6773	400	497	1243	119	33	7	9826
1982	1	2	731	1057	2848	205	379	730	62	65	6080
1983	75	11	149	663	554	1653	208	104	409	35	3860
1984	1	72	100	259	350	270	1131	186	166	318	2854
1985	353	9	2146	386	182	199	128	381	53	117	3954
1986	0	89	39	2586	175	143	124	119	174	42	3492
1987	19	0	2081	131	1536	100	58	83	70	111	4190
1988	1	53	53	2199	124	894	111	39	46	100	3619
1989	8	2	1270	85	757	132	326	31	21	45	2677
1990	18	31	8	1334	128	755	69	166	42	42	2593
1991	35	22	466	92	2080	90	393	73	146	61	3458
1992	151	49	249	323	128	1464	89	319	26	91	2891
1993	4	80	283	351	282	87	645	34	155	75	1997
1994	13	34	304	762	153	56	49	129	29	40	1568
1995	4	8	83	546	420	54	26	3	52	17	1213
1996	6	4	34	496	872	424	61	18	3	73	1992
1997	1	30	103	85	549	488	196	13	8	34	1507
1998	19	19	198	295	265	547	453	116	12	35	1960
1999	2	27	44	752	319	248	346	255	99	25	2117
2000	1	6	318	443	1249	250	201	209	182	65	2924
2001	0	23	67	1719	525	831	255	199	226	194	4041
2002	0	1	358	222	1862	370	657	110	106	278	3964
2003	486	5	9	1806	281	1459	419	470	107	227	5269
2004	2	249	18	63	3602	588	1482	513	418	260	7195
2005	0	11	211	29	222	6835	519	804	126	154	8911

Table 12. Average weight at age (kg) of haddock from the Canadian commercial groundfish fishery from EGB during 1969-2005. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.417	1.762	1.940	2.339	2.657	2.377
2003	0.475	0.758	1.381	1.589	1.851	1.894	2.343	2.839
2004	0.482	0.589	1.102	1.514	1.643	1.880	2.002	2.282
2005	0.056[1]	0.697	0.989	1.433	1.685	1.857	2.041	2.059
Low	0.056	0.589	0.812	1.272	1.643	1.631	2.002	2.032
High	0.797	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600	0.987	1.381	1.787	2.141	2.505	2.864	3.104
Average	0.569	0.982	1.366	1.787	2.129	2.454	2.793	3.047
2003-05	0.338	0.681	1.157	1.512	1.726	1.877	2.129	2.393

[1]One haddock measured.

Table 13. Average lengths at age (cm) of haddock from the EGB Canadian commercial fishery during 1969-2005. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1985		43.2	47.6	56.1	56.8	63.6	66.3	65.8
1986	33.7	43.8	50.1	56.2	63.4	62.8	68.7	72.3
1987		41.4	49.2	56.6	57.5	60.2	62.9	68.2
1988	32.8	43.7	48.4	53.7	58.1	58.1	64.1	64.1
1989		41.8	49.7	53.8	57.8	61.2	62.3	64.1
1990	37.9	43.5	50.2	52.9	58.0	57.8	62.0	59.3
1991	36.2	47.0	47.0	54.2	56.0	61.5	58.9	63.2
1992	35.7	46.4	52.6	52.6	58.1	56.3	64.0	61.2
1993	38.3	46.4	53.4	58.1	56.9	61.6	64.0	65.1
1994	32.5	46.1	52.6	58.1	61.6	59.5	62.8	65.4
1995	40.2	45.0	50.8	56.2	60.8	62.4	63.5	64.2
1996	36.4	44.5	50.0	53.8	58.6	60.0	66.6	56.5
1997	38.6	47.2	48.8	53.4	57.0	60.2	64.4	66.9
1998	36.5	46.1	51.6	52.8	55.7	58.7	63.3	67.2
1999	38.7	45.6	51.5	55.1	54.5	57.4	60.5	62.4
2000	38.5	45.6	50.4	55.2	58.2	56.3	59.9	62.6
2001	32.1	45.5	50.4	53.5	56.9	59.2	57.6	60.3
2002	32.5	44.3	49.7	53.5	55.2	58.9	61.5	59.0
2003	34.2	40.2	49.3	51.6	54.4	54.8	58.9	63.1
2004	34.5	36.9	45.6	50.8	52.3	54.7	55.9	58.3
2005	16.5[1]	38.8	44.0	49.8	52.8	54.5	56.1	56.3
Low	32.1[2]	36.9	44.0	49.8	52.3	54.5	55.9	56.3
High	40.2	47.2	53.4	58.1	63.4	63.6	68.7	72.3
Median	36.0	44.5	50.0	53.8	57.0	59.2	62.8	63.2
Average	34.8	44.0	49.7	54.2	57.2	59.0	62.1	63.1
2003-05	28.4	38.7	46.3	50.8	53.1	54.6	57.0	59.2

[1]One haddock measured.
[2]Excludes 16.5 cm value in 2005.

Table 14. Weights and lengths at age for USA and Canadian commercial haddock fisheries on EGB in 2005.

	Age Group								
	1	2	3	4	5	6	7	8	9+
Weights									
USA Landings	0	0.963	0.919	1.306	1.499	1.606	1.705	2.007	2.332
USA Discards	0.156	0.252	0.683	0.870	1.159	1.108	1.252	1.230	1.369
USA Catch	0.156	0.252	0.766	1.221	1.469	1.573	1.688	1.981	2.308
Canadian Groundfishery	0.056	0.697	0.989	1.433	1.685	1.857	2.041	2.059	2.221
EGB Total Catch[1]	0.156	0.460	0.982	1.426	1.678	1.842	2.010	2.054	2.228
Lengths									
US landings	0	0	46.3	46.2	51.6	53.8	55.0	56.1	
Canadian groundfishery	16.5	38.8	44.0	49.8	52.8	54.5	56.1	56.3	59.0

[1]Excludes Canadian scallop fishery discards.

Table 15. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2006.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1
2006	Polyvalent	Albatross IV	1		

Table 16. Total swept area estimates of abundance at age (numbers in 000's) of EGB haddock from DFO surveys during 1986-2006.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12659	2980	2644	647	528	2420	56760
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883
2005	1669	20958	531	1557	25559	3403	4815	1087	548	60125
2006	9451	5831	185072	2671	2319	15894	775	1646	262	223920

Table 17. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from NMFS spring surveys during 1968-2006. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104
2005	540	32911	257	614	5818	671	1196	240	67	42313
2006	2961	1247	48882	213	949	6650	325	574	187	61988

Table 18. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from NMFS fall surveys during 1963-2005. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	652	6656	3601	585	0	87	96	30	0	11707
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613
2004	2864	116289	322	775	17200	1034	2410	416	528	141837
2005	4981	3114	95159	340	532	3631	347	242	155	108502

Table 19. Average weight at age (kg) of EGB haddock from DFO surveys during 1986-2006, which are used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
2005	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.444
2006	0.059	0.171	0.389	0.657	0.870	1.366	1.591	1.742	2.355
Low	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.216
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.112	0.487	0.922	1.346	1.807	2.160	2.343	2.705	3.171
Average	0.104	0.458	0.868	1.313	1.733	2.086	2.411	2.647	3.128

Table 20. Average lengths at age (cm) of EGB haddock from DFO surveys during 1986-2006.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	22.9	36.2	45.4	51.0	63.7	61.9	67.8	66.0	70.7
1987	24.2	36.3	39.7	53.4	57.1	61.1	65.1	65.8	69.6
1988	22.3	36.4	45.1	55.7	55.9	58.0	62.4	65.8	71.5
1989	19.5	35.9	39.1	50.4	56.8	61.3	58.0	64.6	66.3
1990	24.7	35.8	44.4	48.0	55.9	58.7	61.6	63.1	67.5
1991	23.1	40.7	42.7	51.7	52.9	60.2	58.3	65.1	67.8
1992	23.2	39.2	47.7	46.8	57.7	62.5	63.9	60.3	68.1
1993	23.6	36.6	49.7	55.5	50.0	60.4	59.3	63.7	67.3
1994	22.3	35.8	45.8	53.8	57.6	58.5	65.9	66.5	65.4
1995	20.2	36.3	45.1	52.7	59.0	62.5		65.0	66.0
1996	24.2	36.2	44.4	50.1	56.9	62.7	66.2	61.8	68.4
1997	23.6	37.1	42.1	48.9	54.2	59.5	62.4	63.5	66.8
1998	21.8	37.6	46.4	47.3	52.9	57.2	62.5	69.3	68.7
1999	23.7	35.9	44.8	49.8	48.9	56.1	58.9	63.6	66.6
2000	22.7	37.6	44.3	52.1	56.4	54.7	59.6	61.7	64.7
2001	21.7	37.5	46.1	51.1	56.2	60.0	59.0	62.5	65.5
2002	21.5	31.8	42.1	47.5	52.0	58.1	60.3	59.2	64.4
2003	20.2	34.0	43.3	46.8	52.0	53.8	61.2	61.3	63.3
2004	19.1	31.8	42.0	47.9	50.6	53.3	55.3	59.1	60.2
2005	15.1	29.1	37.2	41.1	49.7	51.6	53.8	54.3	62.7
2006	18.7	27.0	34.0	40.2	42.6	51.8	52.8	55.7	62.2
Low	15.1	27.0	34.0	40.2	42.6	51.6	52.8	54.3	60.2
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	22.3	36.2	44.4	50.1	55.9	58.7	60.8	63.5	66.6
Average	21.8	35.5	43.4	49.6	54.2	58.3	60.7	62.8	66.4

Table 21. Statistical properties of estimates of population abundance (numbers in 000's) at time 2006 and survey calibration constants (unitless, survey:population) for EGB haddock obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	33212	21028	0.633	5354	0.161
2	7638	3249	0.425	635	0.083
3	240173	77809	0.324	14569	0.061
4	970	279	0.287	52	0.053
5	1708	454	0.266	55	0.032
6	16849	4925	0.292	745	0.044
7	2097	597	0.285	59	0.028
8	1967	773	0.393	95	0.048
		Survey Calibration Constants			
DFO Survey					
1	0.225	0.043	0.190	0.003	0.014
2	0.438	0.088	0.201	0.004	0.010
3	0.900	0.182	0.203	0.012	0.013
4	0.925	0.185	0.200	0.014	0.016
5	1.040	0.208	0.200	0.008	0.008
6	0.904	0.178	0.196	0.019	0.021
7	1.069	0.225	0.210	0.023	0.022
8	1.143	0.229	0.200	0.017	0.015
NMFS Spring Survey – Yankee 36 – 1969-72/1982-2006					
1	0.127	0.022	0.173	0.001	0.007
2	0.330	0.056	0.170	0.006	0.017
3	0.437	0.074	0.170	0.004	0.010
4	0.429	0.073	0.169	0.003	0.007
5	0.497	0.089	0.178	0.006	0.012
6	0.407	0.071	0.175	0.006	0.016
7	0.426	0.075	0.177	0.009	0.020
8	0.513	0.090	0.176	0.004	0.007
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.223	0.072	0.325	0.011	0.049
2	0.509	0.160	0.315	0.021	0.042
3	0.637	0.208	0.327	0.023	0.036
4	0.794	0.276	0.347	0.051	0.064
5	0.947	0.316	0.334	0.054	0.057
6	0.889	0.340	0.382	0.045	0.050
7	1.491	0.514	0.345	0.095	0.064
8	0.659	0.256	0.388	0.051	0.077
NMFS Fall Survey					
0	0.126	0.019	0.151	0.001	0.010
1	0.296	0.048	0.162	0.004	0.013
2	0.238	0.035	0.146	0.000	0.002
3	0.237	0.036	0.153	0.004	0.016
4	0.187	0.031	0.167	0.002	0.009
5	0.166	0.025	0.151	0.000	0.000

Table 22. Beginning of year population abundance (numbers in 000's) for EGB haddock during 1969-2006 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2006.

Year	Age Group											
	1	2	3	4	5	6	7	8	9	1+	2+	3+
1969	796	195	3975	863	893	8421	2790	184	780	18896	18100	17905
1970	3469	651	143	1958	471	436	4309	1545	458	13441	9972	9321
1971	452	2772	455	111	1290	250	240	2493	1138	9199	8747	5975
1972	5615	370	1159	147	64	830	63	55	1922	10225	4610	4239
1973	11520	4274	302	600	56	33	598	17	1208	18609	7089	2815
1974	3390	8424	1897	242	159	12	19	454	846	15443	12053	3629
1975	3261	2739	4861	1311	198	102	7	15	985	13479	10218	7479
1976	54641	2650	1981	2617	880	158	52	4	790	63774	9133	6483
1977	5834	44348	2029	1468	1405	601	130	25	634	56475	50641	6293
1978	4134	4767	28983	1603	1040	883	349	106	514	42379	38245	33478
1979	52558	3376	3620	14541	1161	698	452	213	491	77110	24551	21175
1980	6655	42779	2746	2774	8055	624	396	180	525	64733	58077	15299
1981	5078	5411	19054	1942	2002	4464	340	212	520	39024	33946	28535
1982	1773	4099	3791	9549	1236	1196	563	173	564	24945	23171	19072
1983	2628	1448	2677	2152	5251	825	642	1446	492	17561	14934	13485
1984	15228	2137	1046	1587	1263	2832	489	432	1196	26211	10983	8846
1985	1613	12385	1659	623	985	796	1318	237	906	20522	18910	6525
1986	13653	1309	8130	1001	345	629	538	743	784	27133	13480	12171
1987	1301	11083	1035	4345	666	156	405	337	1062	20390	19089	8006
1988	15538	1063	7188	729	2178	455	75	257	982	28467	12929	11865
1989	802	12655	823	3899	485	995	274	28	885	20847	20044	7390
1990	2515	654	9213	596	2509	279	523	197	688	17175	14660	14006
1991	1878	2027	528	6332	374	1375	167	280	649	13610	11733	9706
1992	8208	1515	1232	350	3295	224	772	73	576	16246	8038	6522
1993	11741	6664	1012	716	173	1387	106	346	426	22571	10829	4165
1994	13165	9533	5187	509	335	65	565	56	432	29847	16683	7149
1995	4685	10733	7523	3536	275	222	8	345	336	27663	22978	12245
1996	6020	3821	8701	5655	2509	176	159	4	494	27540	21519	17699
1997	16978	4914	3093	6662	3824	1662	87	113	338	37671	20693	15779
1998	7215	13839	3924	2454	4942	2677	1179	59	330	36620	29404	15565
1999	26033	5878	11133	2933	1762	3535	1771	860	276	54181	28148	22270
2000	10874	21239	4767	8408	2108	1215	2578	1217	818	53223	42349	21110
2001	72214	8877	17084	3491	5725	1497	809	1916	1438	113053	40839	31962
2002	4273	58968	7200	12383	2372	3913	988	478	2354	92929	88656	29688
2003	1756	3489	47907	5686	8402	1598	2591	707	1964	74101	72345	68857
2004	338427	1429	2841	37506	4393	5529	922	1686	1882	394616	56189	54760
2005	8582	276353	1154	2267	27340	3063	3166	287	2302	324513	315932	39579
2006	27858	7003	225604	918	1653	16104	2038	1872	1871	284920	257062	250060

Table 23. Fishing mortality rate for EGB haddock during 1969-2005 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2006. The aggregated rates are weighted by population numbers. The rate for 4+ is also shown as exploitation rate (%).

Year	Age Group												
	1	2	3	4	5	6	7	8	9+	4+	4+ (%)	4-8	5-8
1969	0.001	0.110	0.508	0.405	0.517	0.470	0.391	0.762	0.500	0.459	0.336	0.456	0.460
1970	0.024	0.159	0.056	0.218	0.435	0.399	0.347	0.305	0.603	0.332	0.258	0.318	0.347
1971	0.000	0.672	0.926	0.352	0.241	1.170	1.280	0.411	0.495	0.459	0.336	0.450	0.453
1972	0.073	0.002	0.458	0.774	0.447	0.128	1.097	0.374	0.290	0.291	0.230	0.292	0.222
1973	0.113	0.612	0.023	1.128	1.352	0.379	0.074	0.744	0.163	0.406	0.304	0.630	0.206
1974	0.013	0.350	0.170	0.000	0.249	0.265	0.013	0.071	0.082	0.083	0.073	0.085	0.117
1975	0.007	0.124	0.419	0.198	0.025	0.475	0.366	0.191	0.034	0.134	0.114	0.195	0.182
1976	0.009	0.067	0.100	0.422	0.182	0.000	0.511	0.000	0.025	0.291	0.230	0.348	0.170
1977	0.002	0.225	0.036	0.145	0.264	0.344	0.001	0.973	0.025	0.195	0.161	0.225	0.279
1978	0.002	0.075	0.490	0.123	0.199	0.469	0.294	0.109	0.020	0.210	0.172	0.234	0.309
1979	0.006	0.007	0.066	0.391	0.421	0.367	0.722	0.251	0.032	0.389	0.294	0.399	0.446
1980	0.007	0.609	0.146	0.126	0.390	0.408	0.424	0.367	0.027	0.318	0.248	0.331	0.392
1981	0.014	0.156	0.491	0.252	0.315	0.355	0.473	0.182	0.016	0.307	0.241	0.324	0.344
1982	0.003	0.226	0.366	0.398	0.204	0.422	0.373	0.493	0.132	0.371	0.283	0.380	0.348
1983	0.007	0.125	0.323	0.333	0.417	0.322	0.198	0.361	0.080	0.357	0.274	0.371	0.381
1984	0.007	0.053	0.318	0.277	0.262	0.565	0.525	0.533	0.338	0.418	0.312	0.433	0.482
1985	0.008	0.221	0.305	0.390	0.249	0.192	0.373	0.282	0.151	0.275	0.219	0.303	0.287
1986	0.009	0.035	0.427	0.207	0.597	0.239	0.268	0.287	0.059	0.240	0.194	0.283	0.317
1987	0.002	0.233	0.150	0.490	0.181	0.526	0.254	0.257	0.123	0.381	0.289	0.427	0.251
1988	0.005	0.056	0.412	0.207	0.583	0.307	0.795	0.216	0.118	0.383	0.290	0.454	0.514
1989	0.004	0.117	0.122	0.241	0.353	0.443	0.130	1.674	0.057	0.257	0.206	0.288	0.390
1990	0.016	0.014	0.175	0.267	0.401	0.311	0.424	0.267	0.069	0.329	0.255	0.372	0.390
1991	0.014	0.297	0.211	0.453	0.310	0.377	0.631	0.841	0.109	0.427	0.317	0.451	0.444
1992	0.008	0.204	0.343	0.504	0.665	0.550	0.602	0.497	0.191	0.587	0.406	0.635	0.645
1993	0.008	0.051	0.487	0.559	0.776	0.698	0.431	0.648	0.206	0.590	0.408	0.650	0.682
1994	0.004	0.037	0.183	0.414	0.210	1.872	0.294	0.873	0.110	0.340	0.262	0.404	0.399
1995	0.004	0.010	0.085	0.143	0.248	0.135	0.503	0.185	0.057	0.146	0.124	0.153	0.196
1996	0.003	0.011	0.067	0.191	0.212	0.505	0.139	2.022	0.183	0.203	0.167	0.204	0.229
1997	0.004	0.025	0.032	0.099	0.157	0.143	0.186	0.083	0.121	0.123	0.105	0.123	0.152
1998	0.005	0.018	0.091	0.131	0.135	0.213	0.116	0.258	0.126	0.151	0.127	0.151	0.157
1999	0.004	0.010	0.081	0.130	0.172	0.116	0.175	0.136	0.106	0.139	0.118	0.140	0.144
2000	0.003	0.018	0.111	0.184	0.142	0.207	0.097	0.184	0.094	0.162	0.136	0.166	0.144
2001	0.003	0.009	0.122	0.187	0.181	0.216	0.327	0.145	0.166	0.187	0.155	0.190	0.191
2002	0.003	0.008	0.036	0.188	0.195	0.212	0.134	0.288	0.143	0.188	0.156	0.193	0.202
2003	0.006	0.005	0.045	0.058	0.219	0.350	0.230	0.185	0.138	0.178	0.148	0.182	0.235
2004	0.003	0.014	0.026	0.116	0.161	0.357	0.966	0.323	0.167	0.169	0.142	0.169	0.329
2005	0.003	0.003	0.028	0.116	0.329	0.207	0.326	0.637	0.076	0.294	0.232	0.308	0.321

Table 24. Beginning of year biomass for EGB haddock during 1969-2006 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2006.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	91	100	3716	1298	1779	19745	7577	539	2686	37532	37441	37340
1970	399	335	134	2944	939	1022	11705	4526	1576	23581	23182	22847
1971	52	1426	425	166	2569	586	651	7302	3919	17097	17045	15618
1972	646	191	1084	222	127	1945	172	160	6620	11165	10520	10329
1973	1324	2199	283	903	111	78	1624	51	4161	10734	9409	7210
1974	390	4334	1773	364	317	28	51	1331	2916	11504	11114	6780
1975	375	1409	4545	1971	395	238	20	44	3393	12391	12016	10607
1976	6281	1364	1852	3936	1754	371	140	12	2721	18432	12151	10787
1977	671	22818	1897	2207	2800	1409	352	74	2186	34415	33745	10926
1978	475	2453	27098	2411	2071	2071	948	310	1772	39609	39133	36681
1979	6042	1737	3384	21868	2313	1636	1228	623	1690	40522	34480	32743
1980	765	22011	2567	4172	16049	1462	1075	527	1808	50435	49670	27660
1981	584	2784	17815	2921	3989	10468	922	621	1793	41897	41313	38529
1982	204	2109	3545	14360	2462	2805	6962	508	1943	34897	34693	32584
1983	302	745	2503	3237	10463	1934	1744	4234	1694	26857	26555	25810
1984	1750	1099	978	2387	2517	6641	1329	1264	4122	22087	20337	19237
1985	185	6372	1552	937	1963	1866	3580	694	3121	20271	20086	13713
1986	1838	591	7921	1446	1051	1791	1935	2509	3072	22155	20317	19726
1987	195	5537	741	7267	1341	397	1276	1062	3852	21667	21472	15935
1988	1511	494	6688	1309	3956	873	205	840	3801	19677	18167	17672
1989	50	6000	535	5430	968	2515	591	80	2779	18948	18898	12898
1990	375	343	8515	704	4672	578	1312	555	2389	19443	19069	18726
1991	225	1388	422	9571	633	3347	352	875	2228	19042	18817	17429
1992	1004	913	1377	371	6848	486	2092	167	1980	15237	14234	13321
1993	1432	3206	1241	1291	221	3235	248	948	1396	13219	11786	8580
1994	1404	4473	5430	825	646	140	1782	152	1332	16183	14779	10306
1995	404	5296	7245	5502	611	544	20	1031	1069	21723	21319	16023
1996	834	1891	7996	7466	4846	449	462	11	1774	25728	24894	23003
1997	2244	2489	2418	8029	6364	3616	213	292	1066	26731	24487	21998
1998	774	7409	4062	2850	7758	5232	3077	210	1143	32514	31740	24331
1999	3375	2784	10140	3783	2218	6607	3775	2340	825	35846	32471	29687
2000	1259	11540	4522	12431	3943	2174	5924	3052	2372	47217	45959	34419
2001	6742	4648	17175	4787	10292	3242	1820	4970	4212	57886	51144	46497
2002	409	19552	5602	14088	3544	7688	2150	1054	6374	60460	60052	40499
2003	141	1289	40533	6044	12411	2629	5722	1577	4886	75230	75089	73800
2004	21624	443	2220	43178	5738	8615	1496	3298	4171	90783	69159	68715
2005	239	60177	568	1579	33521	4046	4847	460	5627	111064	110825	50648
2006	1634	1198	87729	603	1438	21999	3242	3260	4406	125509	123876	122677

Table 25. Partial recruitment of haddock normalized to ages 4 to 8 from the EGB Canadian commecial fishery during 1990-2005.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1990	0.043	0.039	0.470	0.718	1.078	0.836	1.139	0.717	0.187
1991	0.032	0.660	0.468	1.005	0.688	0.836	1.399	1.864	0.242
1992	0.013	0.322	0.541	0.794	1.048	0.867	0.948	0.783	0.301
1993	0.013	0.078	0.750	0.860	1.195	1.074	0.663	0.998	0.318
1994	0.010	0.091	0.454	1.025	0.520	4.631	0.727	2.160	0.273
1995	0.026	0.064	0.557	0.933	1.620	0.883	3.286	1.209	0.371
1996	0.015	0.055	0.329	0.939	1.041	2.481	0.681	9.927	0.897
1997	0.036	0.204	0.257	0.801	1.274	1.163	1.514	0.678	0.986
1998	0.033	0.117	0.601	0.866	0.893	1.408	0.767	1.709	0.830
1999	0.025	0.068	0.576	0.931	1.227	0.827	1.250	0.969	0.753
2000	0.017	0.107	0.672	1.112	0.857	1.248	0.582	1.110	0.567
2001	0.014	0.049	0.642	0.983	0.952	1.137	1.723	0.762	0.876
2002	0.014	0.040	0.187	0.973	1.010	1.099	0.694	1.489	0.738
2003	0.030	0.030	0.246	0.319	1.202	1.927	1.263	1.015	0.757
2004	0.016	0.085	0.152	0.686	0.949	2.110	5.702	1.908	0.988
2005	0.011	0.009	0.093	0.376	1.070	0.674	1.059	2.070	0.247
Avg 2001-03	0.019	0.040	0.358	0.758	1.055	1.387	1.227	1.089	0.791
Avg 2002-04	0.020	0.052	0.195	0.659	1.054	1.712	2.553	1.471	0.828
Avg 2003-05	0.019	0.041	0.164	0.460	1.074	1.570	2.675	1.665	0.664

Table 26. Partial recruitment of haddock normalized to ages 5 to 8 from the EGB Canadian commecial fishery during 1990-2005.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1990	0.041	0.037	0.449	0.686	1.029	0.798	1.087	0.684	0.178
1991	0.032	0.670	0.476	1.021	0.699	0.849	1.421	1.893	0.246
1992	0.013	0.316	0.532	0.781	1.031	0.853	0.933	0.770	0.296
1993	0.012	0.074	0.715	0.819	1.139	1.023	0.632	0.950	0.303
1994	0.011	0.092	0.459	1.038	0.527	4.690	0.737	2.187	0.276
1995	0.020	0.050	0.437	0.731	1.269	0.691	2.574	0.947	0.291
1996	0.013	0.049	0.294	0.836	0.927	2.211	0.607	8.847	0.799
1997	0.029	0.166	0.208	0.650	1.033	0.943	1.228	0.550	0.799
1998	0.031	0.112	0.579	0.835	0.861	1.357	0.739	1.647	0.801
1999	0.025	0.066	0.561	0.908	1.196	0.806	1.218	0.945	0.734
2000	0.020	0.123	0.775	1.282	0.988	1.438	0.671	1.279	0.654
2001	0.014	0.049	0.638	0.977	0.946	1.130	1.713	0.758	0.871
2002	0.013	0.038	0.179	0.932	0.967	1.052	0.665	1.427	0.707
2003	0.023	0.023	0.191	0.247	0.931	1.492	0.978	0.786	0.586
2004	0.008	0.044	0.078	0.354	0.489	1.088	2.939	0.983	0.509
2005	0.010	0.009	0.089	0.361	1.027	0.647	1.016	1.987	0.237
Avg. 2001-03	0.017	0.037	0.336	0.719	0.948	1.225	1.119	0.990	0.722
Avg. 2002-04	0.015	0.035	0.149	0.511	0.796	1.211	1.527	1.065	0.601
Avg. 2003-05	0.014	0.025	0.119	0.321	0.816	1.076	1.644	1.252	0.444

Table 27. Instantaneous rates of change in lengths at age of EGB haddock from DFO surveys during 1986-2005.

Year	Age Group								
	1	2	3	4	5	6	7	8	9
1986	0.460	0.093	0.161	0.114	-0.041	0.051	-0.031	0.044	0.061
1987	0.409	0.217	0.337	0.046	0.016	0.021	0.010	0.060	0.013
1988	0.475	0.072	0.111	0.020	0.092	-0.001	0.035	0.050	-0.079
1989	0.604	0.213	0.206	0.102	0.033	0.005	0.085	-0.025	-0.077
1990	0.501	0.177	0.151	0.097	0.075	-0.006	0.054	0.020	0.076
1991	0.527	0.157	0.092	0.109	0.167	0.060	0.032	0.039	-0.011
1992	0.455	0.237	0.153	0.066	0.047	-0.053	-0.003	0.068	-0.031
1993	0.417	0.224	0.080	0.036	0.158	0.086	0.115	0.021	0.031
1994	0.489	0.232	0.141	0.093	0.081		-0.013	-0.045	0.020
1995	0.584	0.201	0.106	0.077	0.060	0.058		0.036	0.075
1996	0.427	0.152	0.096	0.078	0.045	-0.004	-0.041	0.073	-0.006
1997	0.463	0.224	0.117	0.080	0.053	0.049	0.105	0.069	0.114
1998	0.497	0.176	0.071	0.032	0.058	0.030	0.018	-0.045	-0.011
1999	0.459	0.211	0.152	0.123	0.113	0.059	0.045	0.007	0.012
2000	0.501	0.204	0.142	0.076	0.062	0.075	0.048	0.037	0.070
2001	0.383	0.117	0.030	0.018	0.033	0.006	0.004	0.022	-0.023
2002	0.457	0.307	0.106	0.091	0.035	0.051	0.015	0.036	-0.005
2003	0.453	0.214	0.102	0.078	0.025	0.028	-0.034	0.067	-0.133
2004	0.422	0.156	-0.022	0.036	0.019	0.009	-0.018	0.043	-0.041
2005	0.584	0.155	0.076	0.036	0.041	0.024	0.035	0.090	0.049
Min	0.383	0.072	-0.022	0.018	-0.041	-0.053	-0.041	-0.045	-0.133
Average	0.478	0.187	0.120	0.070	0.059	0.029	0.024	0.033	0.005
Max	0.604	0.307	0.337	0.123	0.167	0.086	0.115	0.090	0.114
Avg (1986-1993)	0.481	0.174	0.162	0.074	0.068	0.020	0.037	0.035	-0.002
Avg (1994-1999)	0.486	0.199	0.114	0.081	0.068	0.038	0.023	0.016	0.034
Avg (2000-2005)	0.467	0.192	0.072	0.056	0.036	0.032	0.008	0.049	-0.014

Table 28. Lengths estimated for the EGB haddock 2003 year class based on growth rates from the 1998, 1999 and 2000 year classes for input into the risk assessment for 2007.

Age	Beginning year length (cm)	Growth rate	Calculated length for following year[2]
3	34.0[1]	0.182	40.8
4	40.8	0.122	46.1
5	46.1	0.075	49.6

[1]Observed 2006 beginning year length for 2003 year class from DFO survey
[2] $length_{a+1} = length_a \times e^{growth\ rate}$

Table 29. Beginning year and fishery lengths and weights estimated for the 5Z haddock 2003 year class for input into the risk assessment for 2007.

Age	Beginning of year			Fishery		
	Length	Weight[2]	- 10%[3]	Length	Weight[2]	- 10%[3]
3	34.0[1]	0.389[1]	N/A	45.0[5]	1.046	0.942
4	40.8[4]	0.786	0.707	48.0[5]	1.263	1.137
5	46.1[4]	1.120	1.010			

[1]Observed 2006 beginning year length or weight for 2003 year class from DFO survey
[2] $weight = 0.0000158 \times length^{2.91612}$
[3]Weight reduced by 10% to reflect drop in conditon
[4]Calculated length
[5]Interpolating between beginning of year lengths using the observed patterns from nearby year classes

Table 30. Input for projections and risk analyses of EGB haddock for the 2007 fishery. A catch of 22,000 mt in 2006 and M = 0.2 were assumed for the forecasts.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2006	27858	7003	225604	918	1653	16104	2038	1872	1871
Partial Recruitment to the Fishery[1]									
2006	0.01	0.03	0.05	0.36	1	1	1	1	1
2007	0.01	0.03	0.05	0.30[2]	1	1	1	1	1
Weight at beginning of year for population (kg)[3]									
2006	0.06	0.17	0.39	0.66	0.87	1.37	1.59	1.74	2.36
2007	0.06	0.17	0.39	0.71[4]	0.87	1.37	1.59	1.74	2.36
2008	0.06	0.17	0.39	0.71[4]	1.01[4]	1.37	1.59	1.74	2.36
Weight at age for catch (kg)[5]									
2006	0.39[6]	0.70	0.94[7]	1.43	1.69	1.86	2.04	2.06	2.22
2007	0.39[6]	0.70	0.94[7]	1.14[7]	1.69	1.86	2.04	2.06	2.22
Maturity									
2005	0	0	1	1	1	1	1	1	1
2006	0	0	1	1	1	1	1	1	1
2007	0	0	1	1	1	1	1	1	1

[1]Estimated from observed 2005 partial recruitment except where indicated.
[2]Derived from relationship between 2003 to 2005 survey lengths at age and partial recruitment values.
[3]Equal to 2006 DFO survey weights except where indicated.
[4]Estimates for the 2003 and 2004 year classes based on a growth model.
[5]Equal to 2005 Canadian fishery weights except where indicated.
[6]Average weight for age 1 in 2001.
[7]Estimates for the 2003 and 2004 year classes based on a growth model.

Table 31. Bias adjusted deterministic projection results for EGB haddock for the 2007 fishery using 20 million recruits for the 2006 year class.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2006	27858	7003	225604	918	1653	16104	2038	1872	1871			
2007	20000	22689	5644	179942	623	802	7816	989	1816			
2008	20000	16332	18432	4561	136269	393	506	4934	1771			
Population Biomass (mt)												
2006	1644	1197	87760	603	1438	21998	3243	3261	4405	125549	123906	122708
2007	1180	3880	2196	127219	542	1096	12435	1723	4277	154547	153367	149487
2008	1180	2793	7170	3225	137360	537	806	8595	4171	165836	164656	161863
Fishing mortality												
2006	0.005	0.016	0.026	0.188	0.523	0.523	0.523	0.523	0.523			
2007	0.003	0.008	0.013	0.078	0.26	0.26	0.26	0.26	0.26			
Projected Catch Numbers (000s)												
2006	132	99	5279	143	615	5995	759	697	696			
2007	47	160	66	12253	130	167	1629	206	379			
Catch Biomass (mt)												
2006	52	69	4973	205	1037	11133	1549	1435	1547	22000		
2007	19	111	62	13932	219	310	3324	424	841	19243		

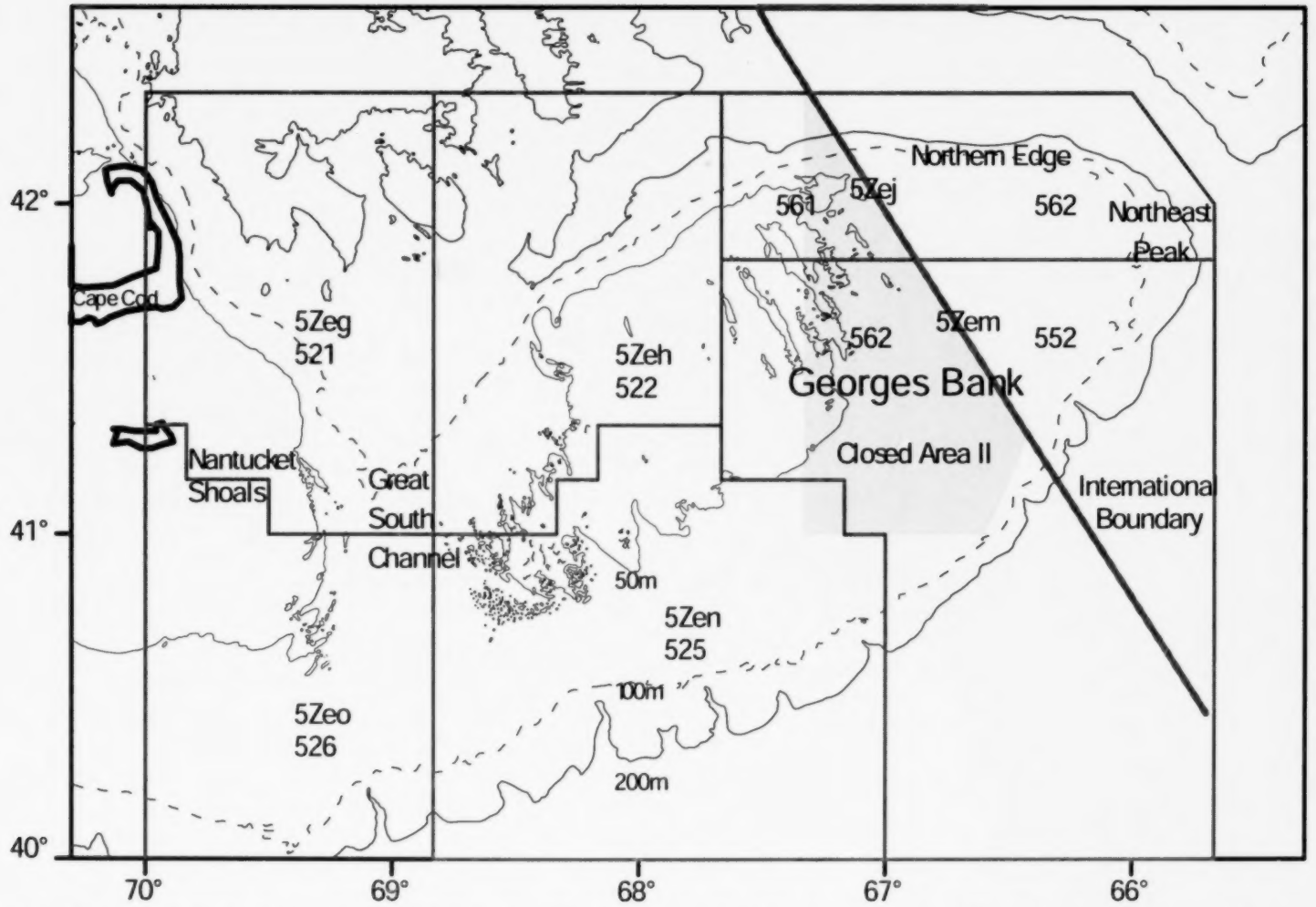

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are DFO designations and numeric codes, e.g. 561, are NMFS designations.

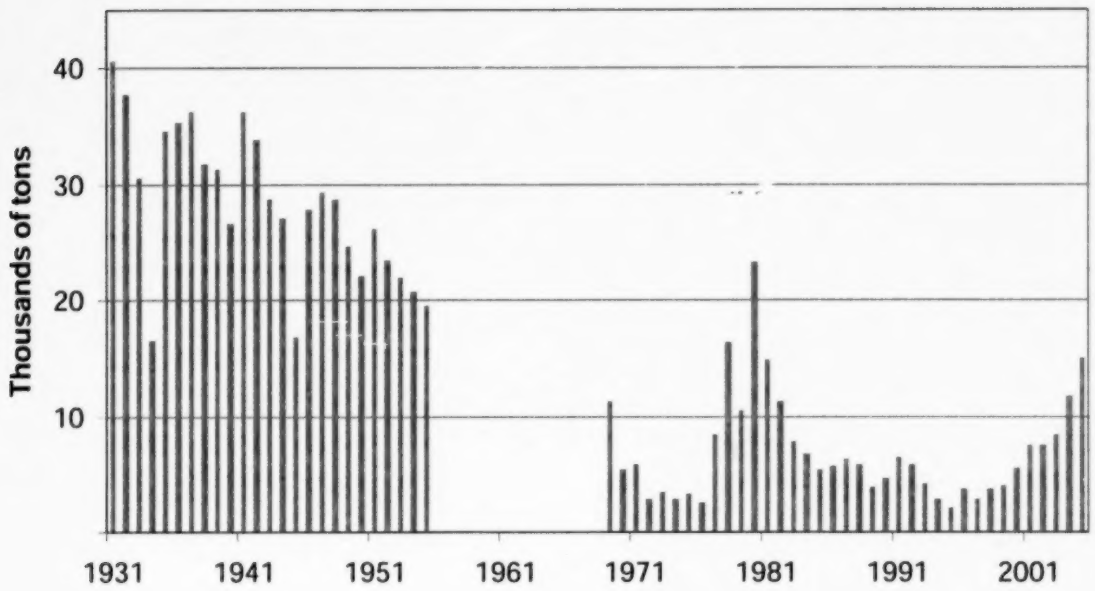

Figure 2. Historical catch of EGB haddock during 1931-1955 compared to recent catches during 1969-2005.

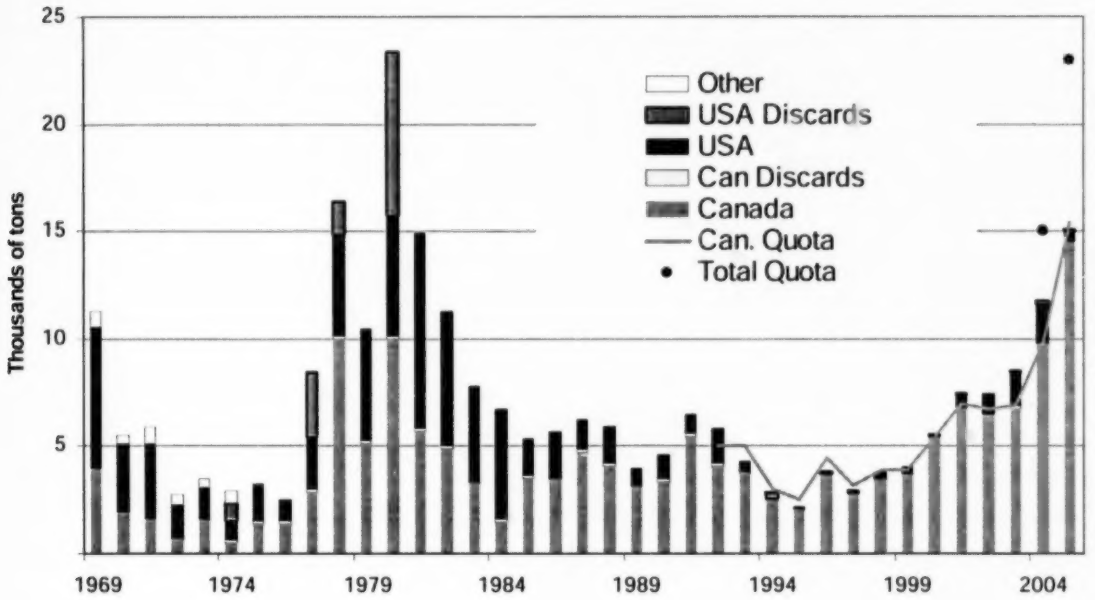

Figure 3. Nominal catch of EGB haddock during 1969-2005.

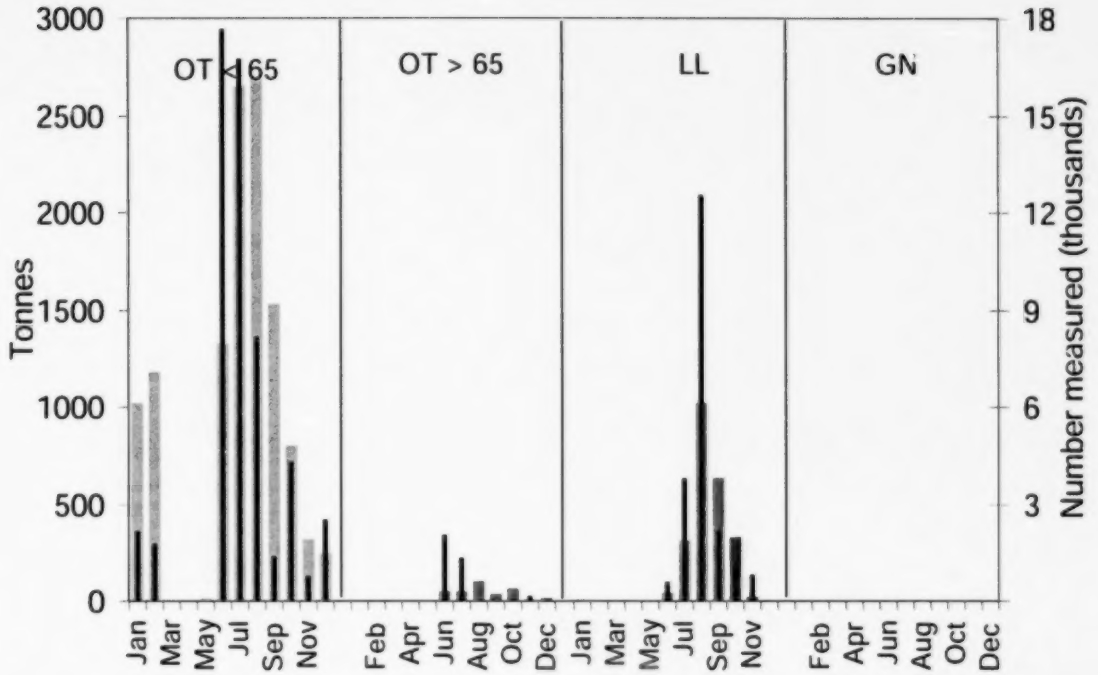

Figure 4. Haddock catches in EGB by month and gear for the Canadian commercial groundfish fishery in 2005 (wide bars) with sampling levels (narrow bars).

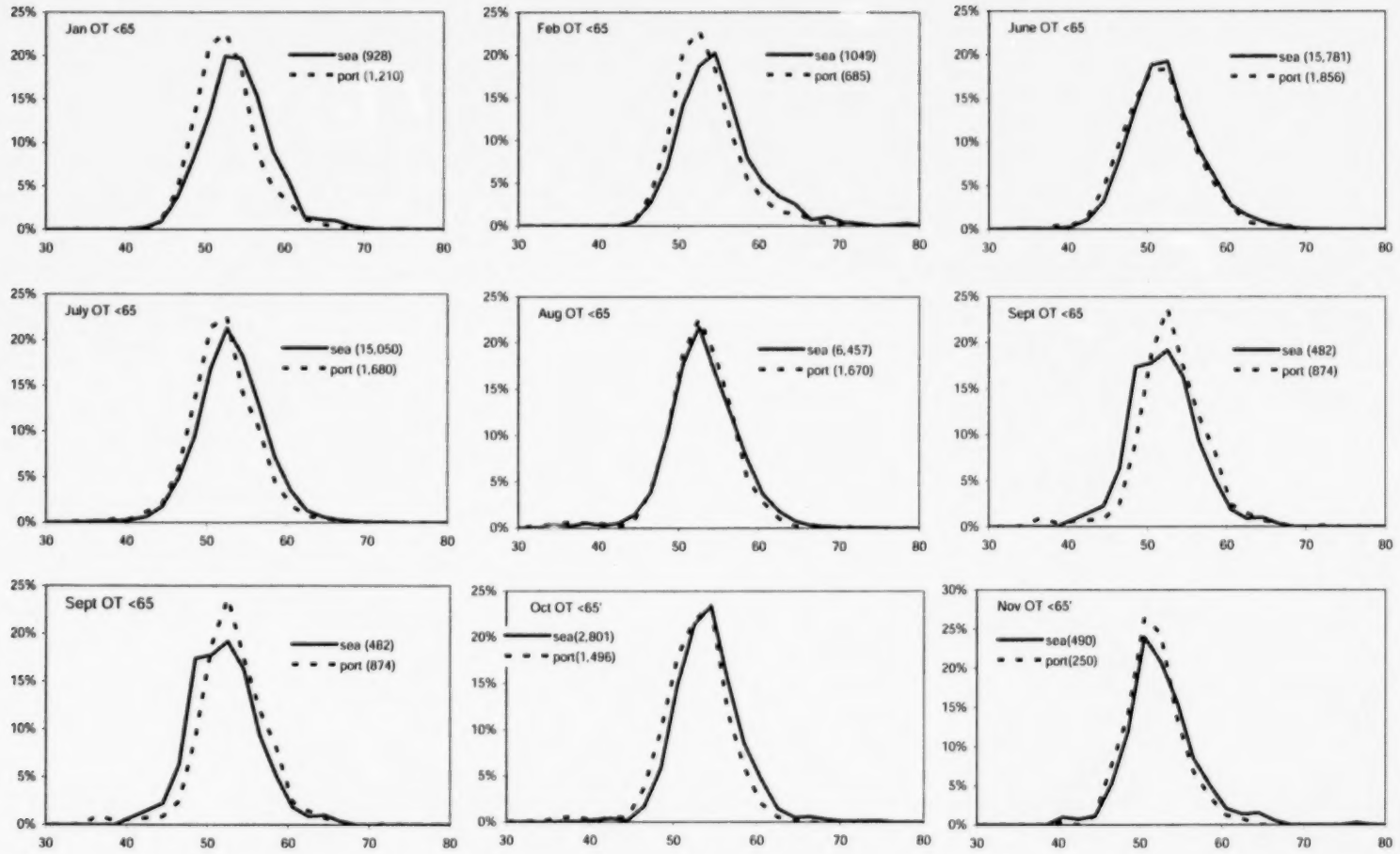

Figure 5. Comparison of length frequencies obtained at port and at sea from the EGB Canadian commercial groundfish fishery in 2005. The number of fish measured is shown in brackets.

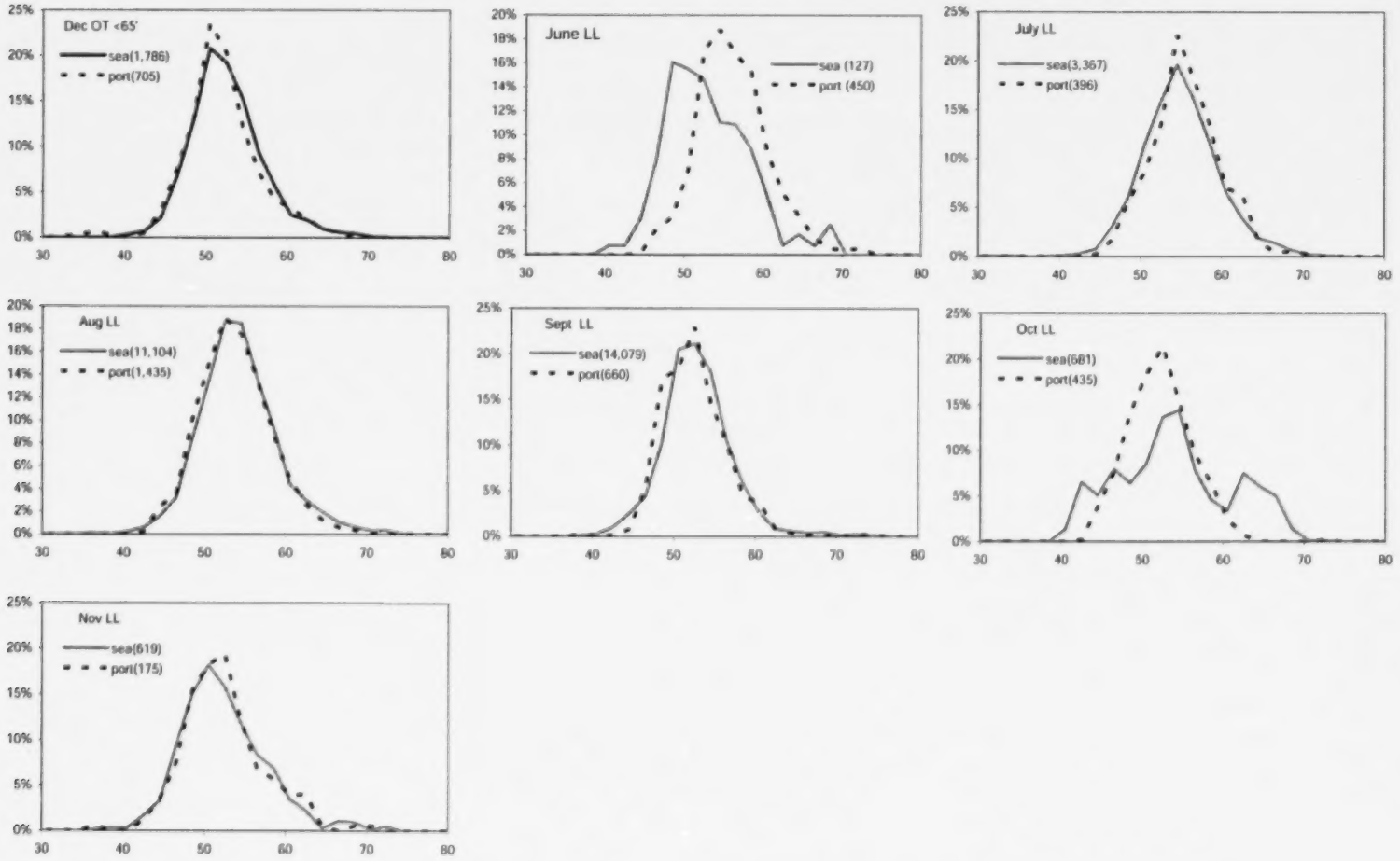

Figure 5 (continued). Comparison of length frequencies obtained at port and at sea from the EGB Canadian commercial groundfish fishery in 2005. The number of fish measured is shown in brackets.

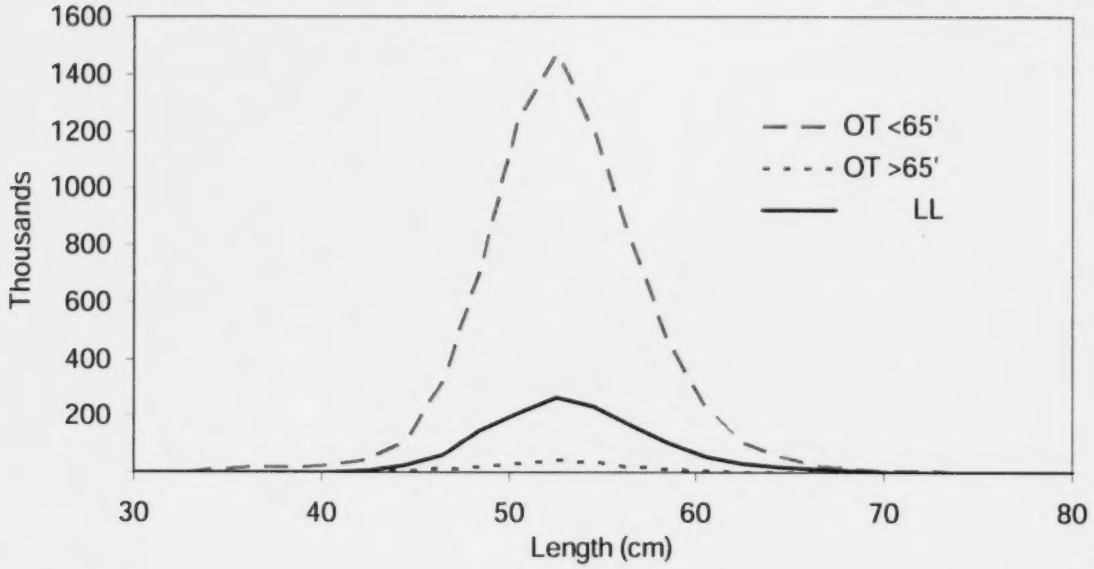

Figure 6. Catch at length by the principal Canadian EGB commercial haddock fisheries in 2005.

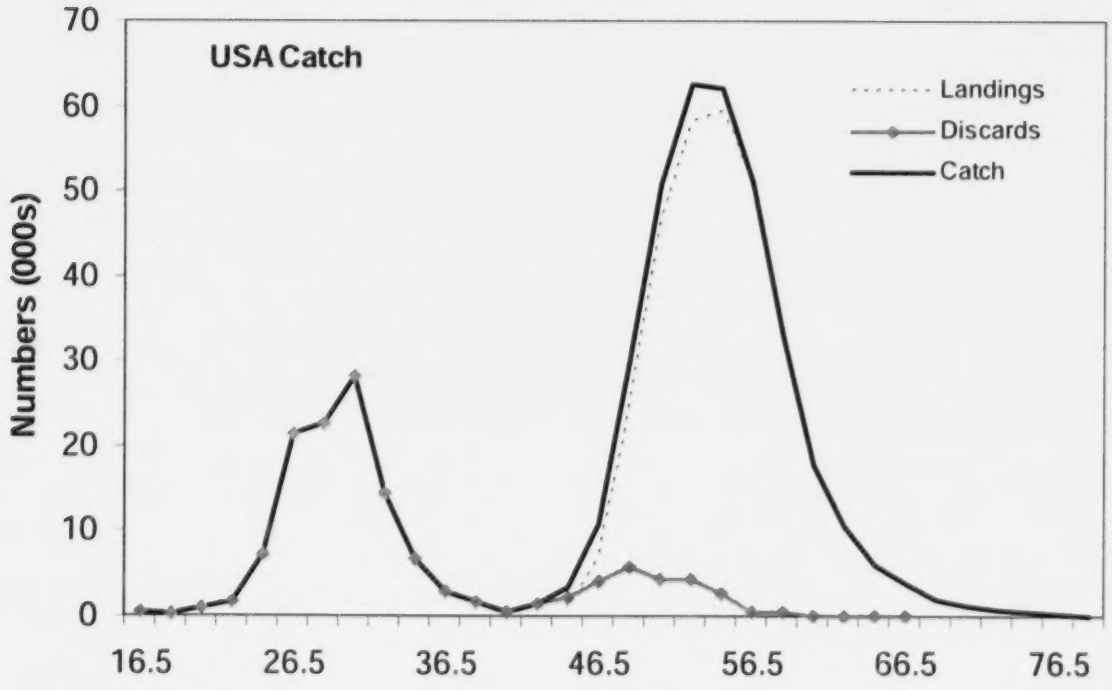

Figure 7. Catch at length by the USA EGB commercial haddock fisheries in 2005.

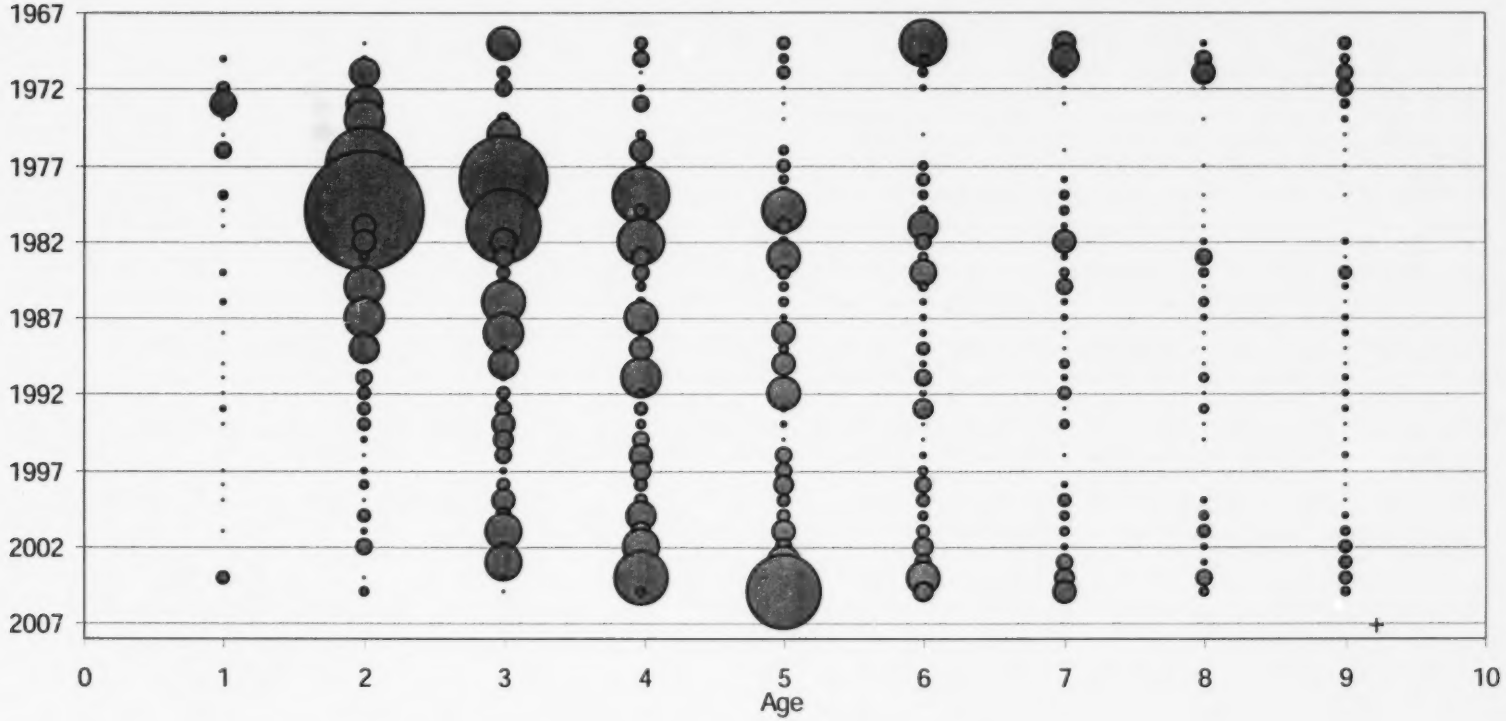

Figure 8. Total commercial catch at age (numbers) of EGB haddock during 1969-2005. The bubble area is proportional to magnitude.

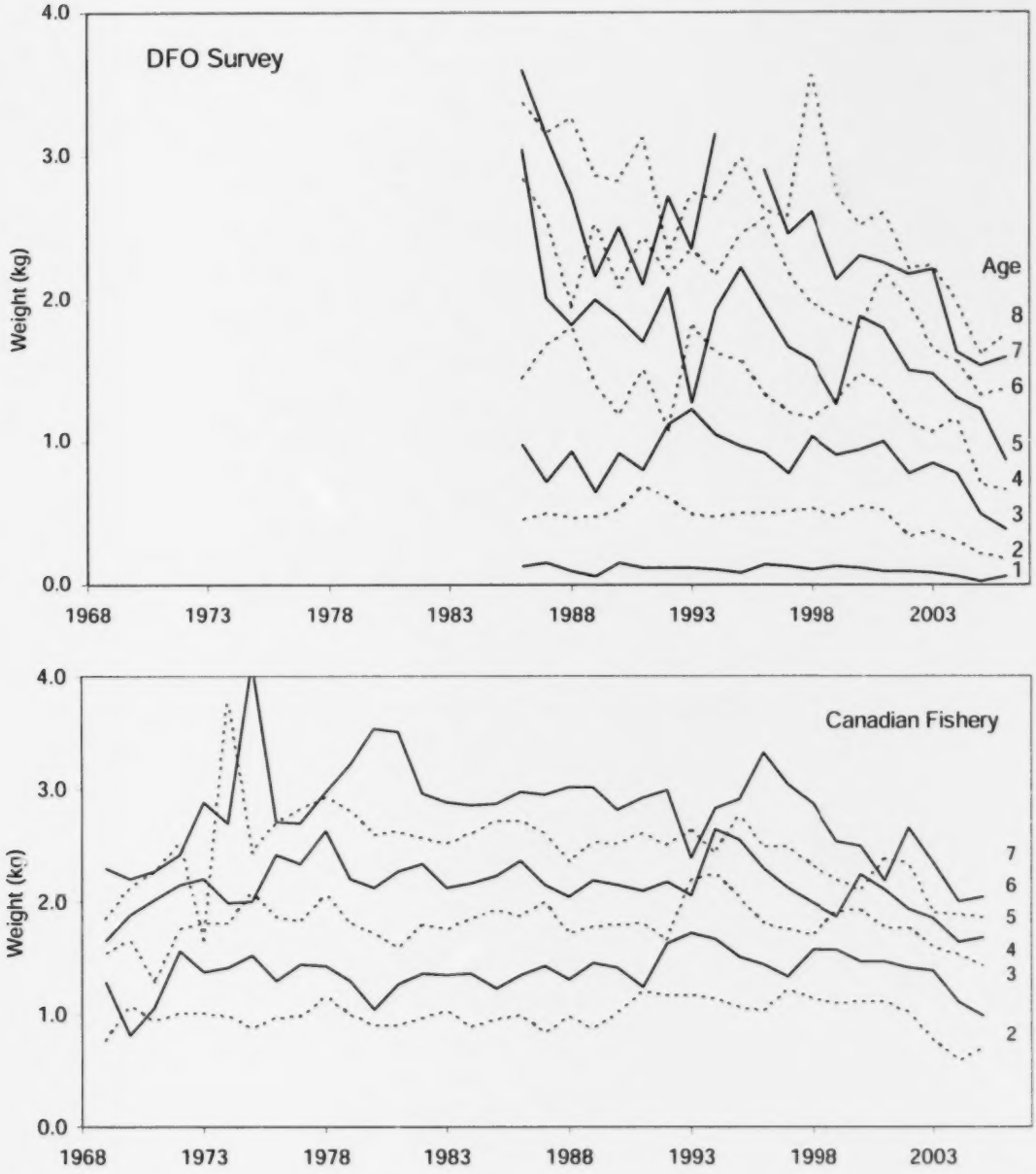

Figure 9. Average weights at age for EGB haddock from the Canadian commercial groundfish fishery during 1969-2005 and from the DFO survey during 1986-2006.

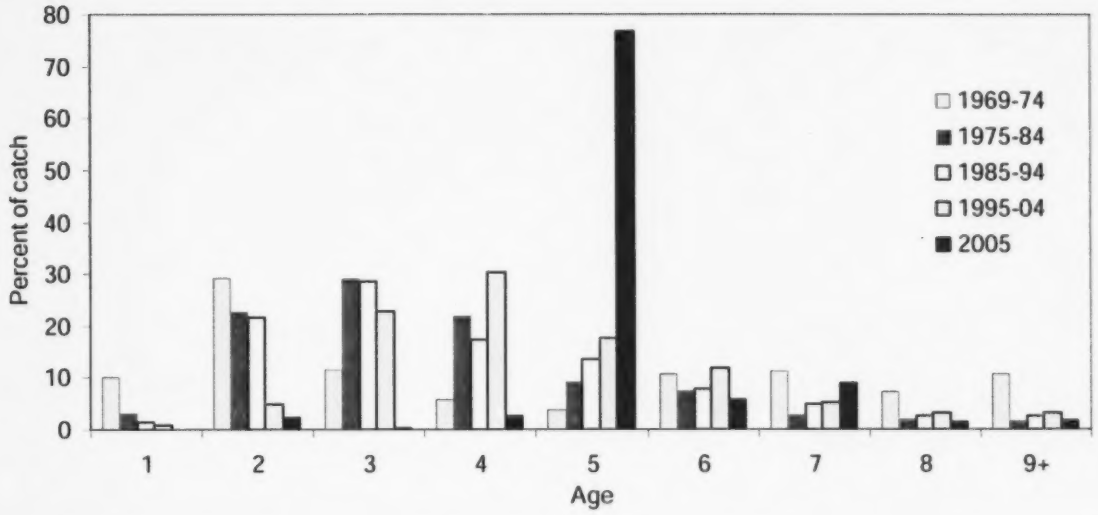

Figure 10. Age composition of the haddock catch for the EGB commercial fishery in 2005 compared to the average age composition for the total catch of all fisheries during 1969-1974, 1975-1984, 1985-1994, and 1995-2004.

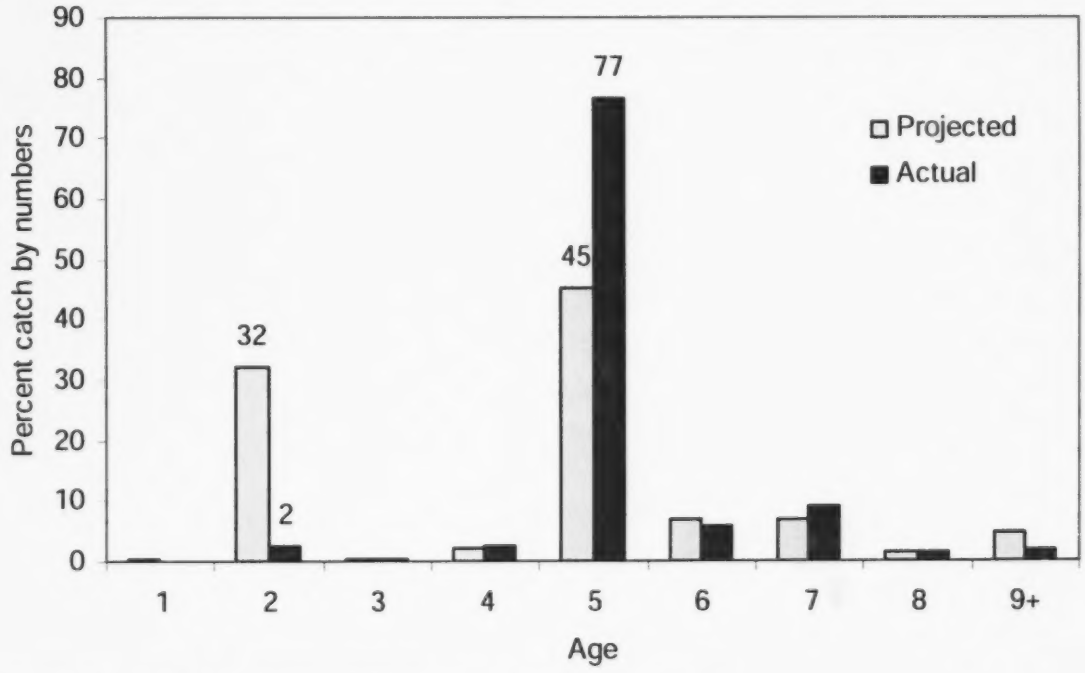

Figure 11. Actual and projected 2005 EGB haddock catch (by numbers).

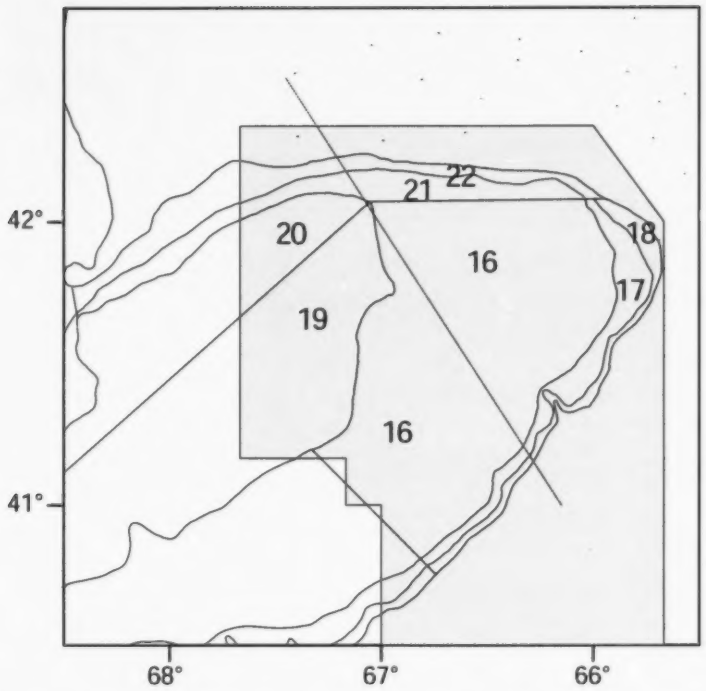

Figure 12. Stratification scheme used for NMFS surveys. The EGB management area is indicated by shading.

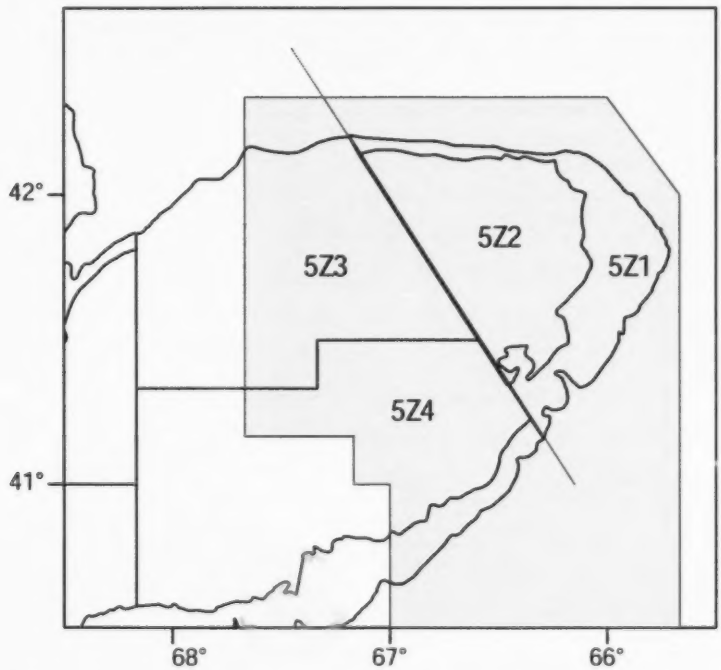

Figure 13. Stratification scheme used for the DFO survey. The EGB management area is indicated by shading.

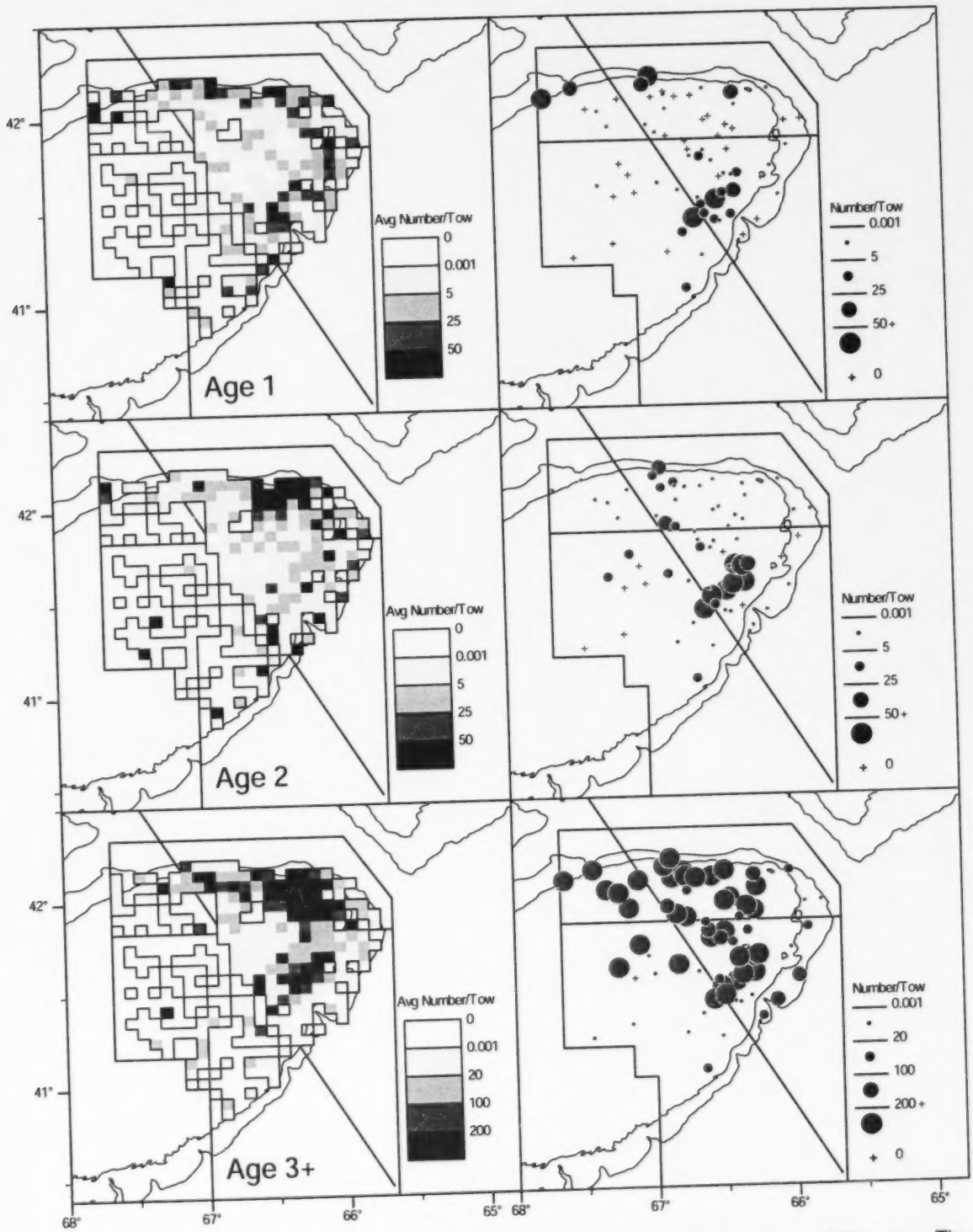

Figure 14. Distribution of EGB haddock abundance (number/tow) as observed from the **DFO** survey. The squares (left panels) are shaded relative to the average catch for 1996 to 2005. The expanding symbols (right panels) represent the **2006** survey catches.

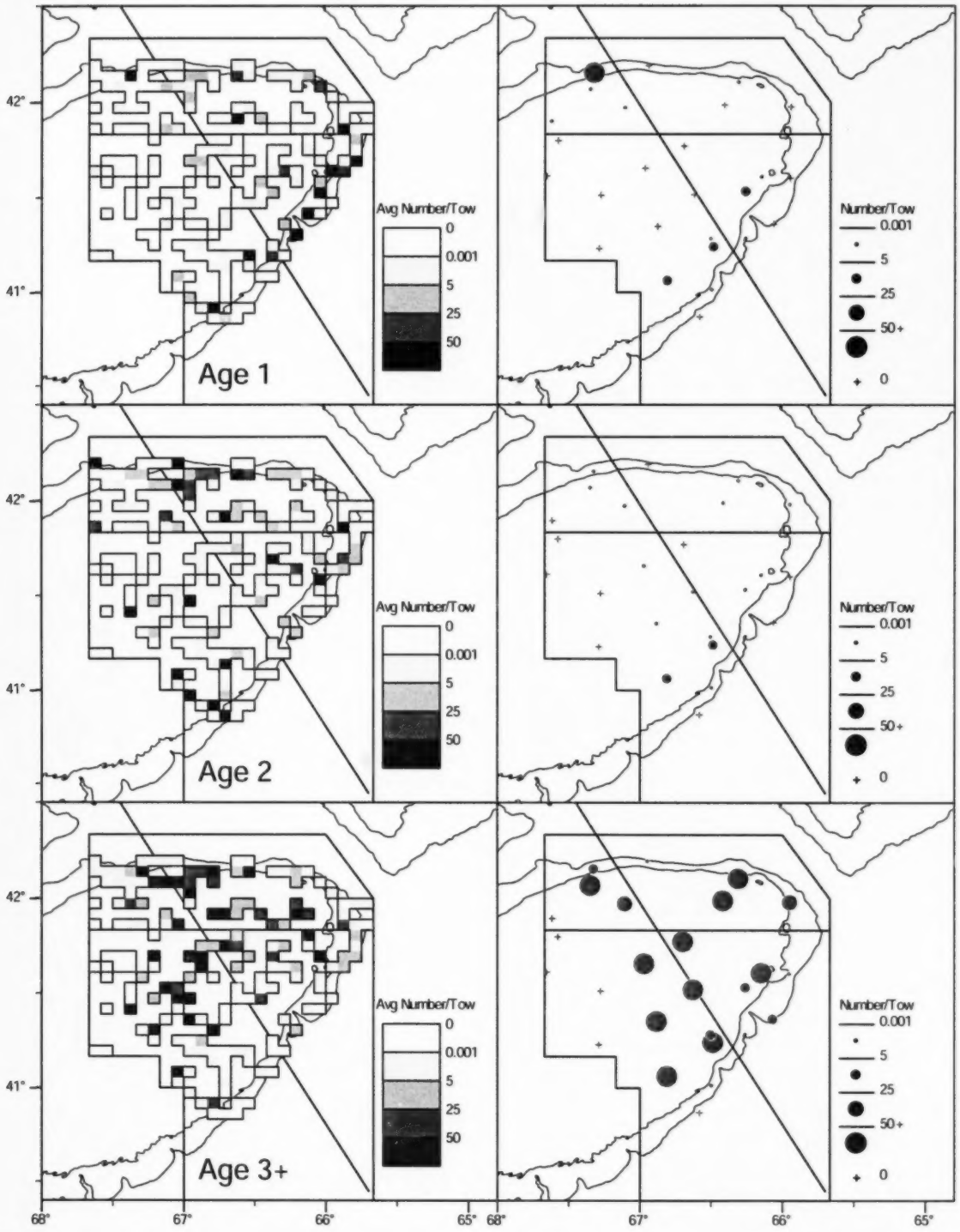

Figure 15. Distribution of EGB haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares (left panels) are shaded relative to the average catch for 1996 to 2005. The expanding symbols (right panels) represent the **2006** survey catches.

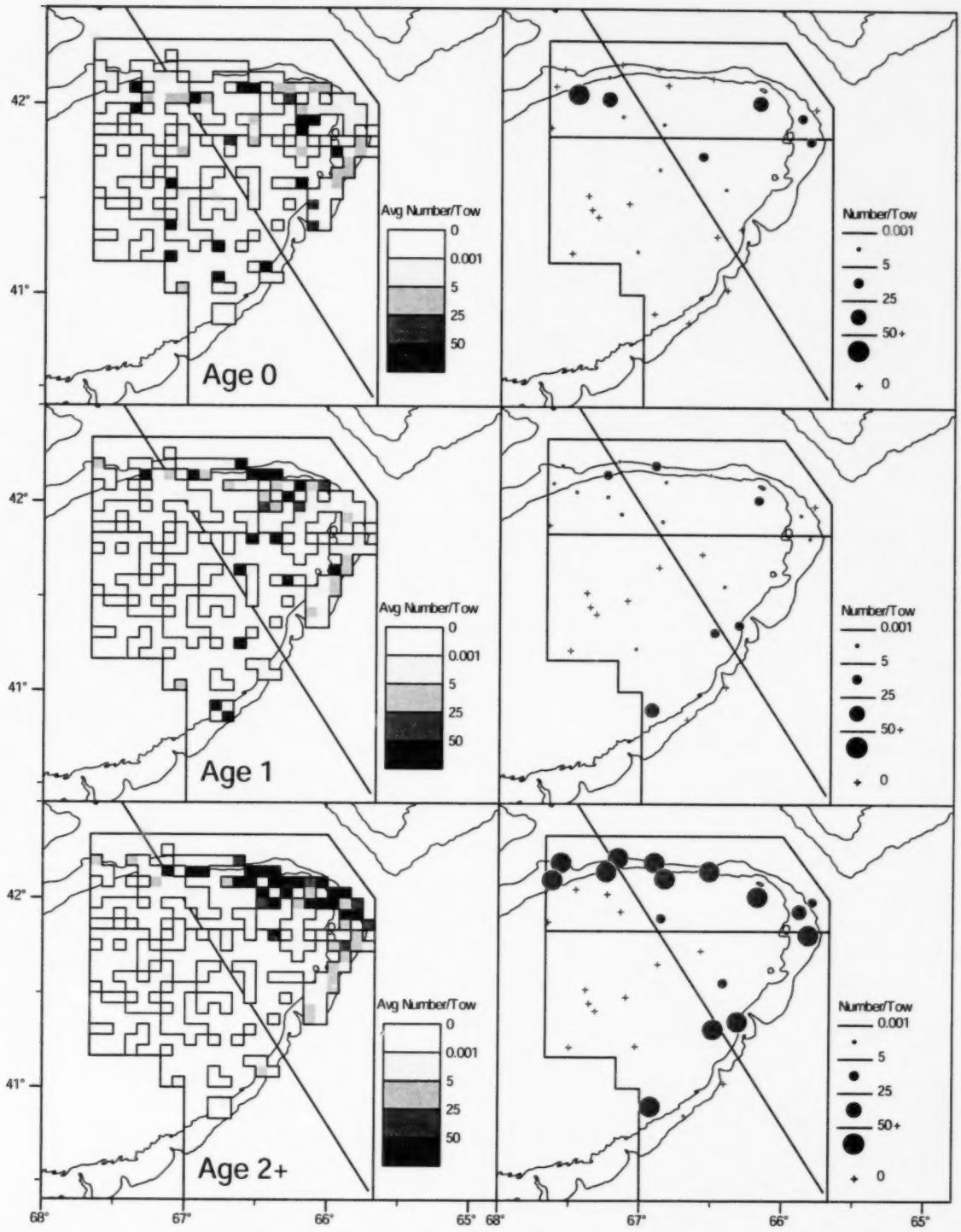

Figure 16. Distribution of EGB haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares (left panels) are shaded relative to the average catch for 1995 to 2004. The expanding symbols (right panels) represent the **2005** survey catches.

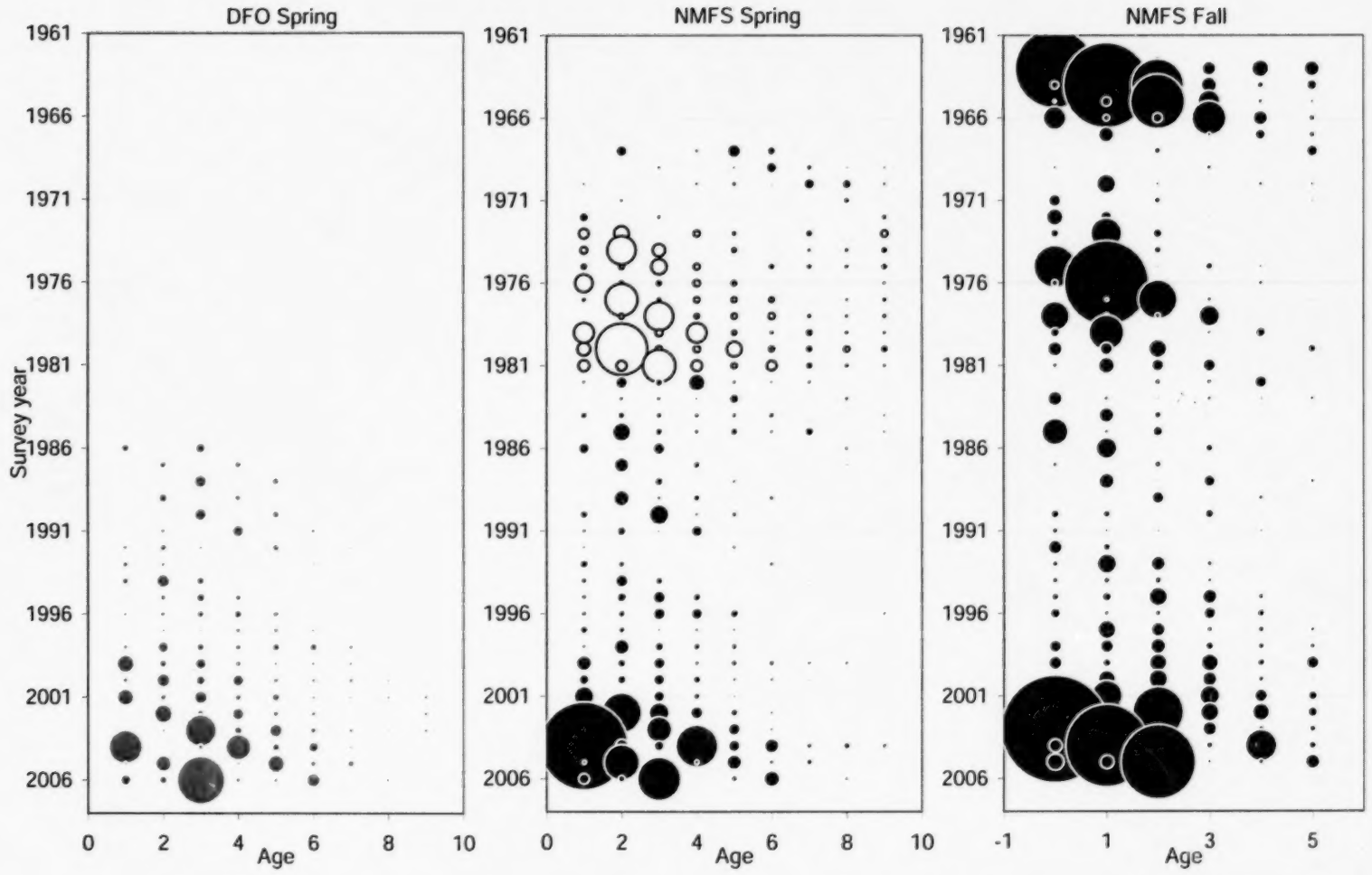

Figure 17. Estimated abundance at age (numbers in 000's) of EGB haddock for the DFO, NMFS spring and NMFS fall surveys during 1963-2006. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

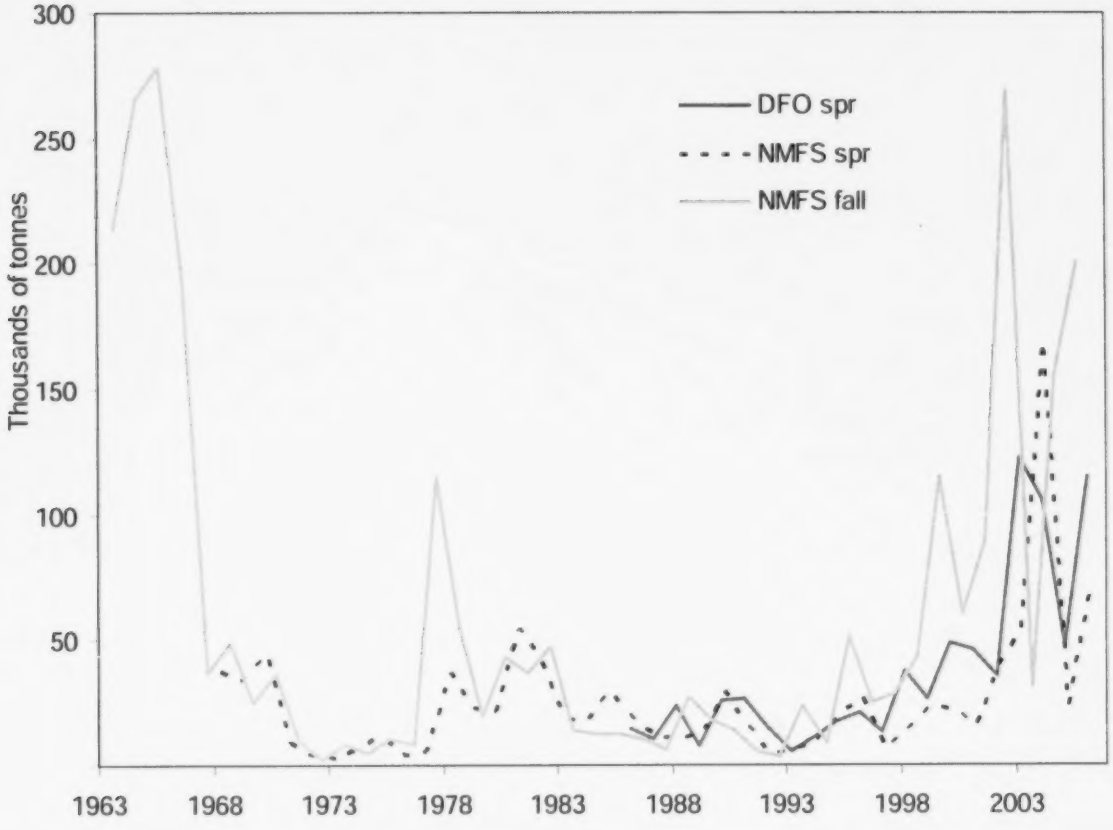

Figure 18. Biomass from NMFS fall (ages 2-8), NMFS spring (ages 3-8) and DFO (ages 3-8) research surveys (scaled by calibration constants, Table 18) for EGB haddock during 1963-2006.

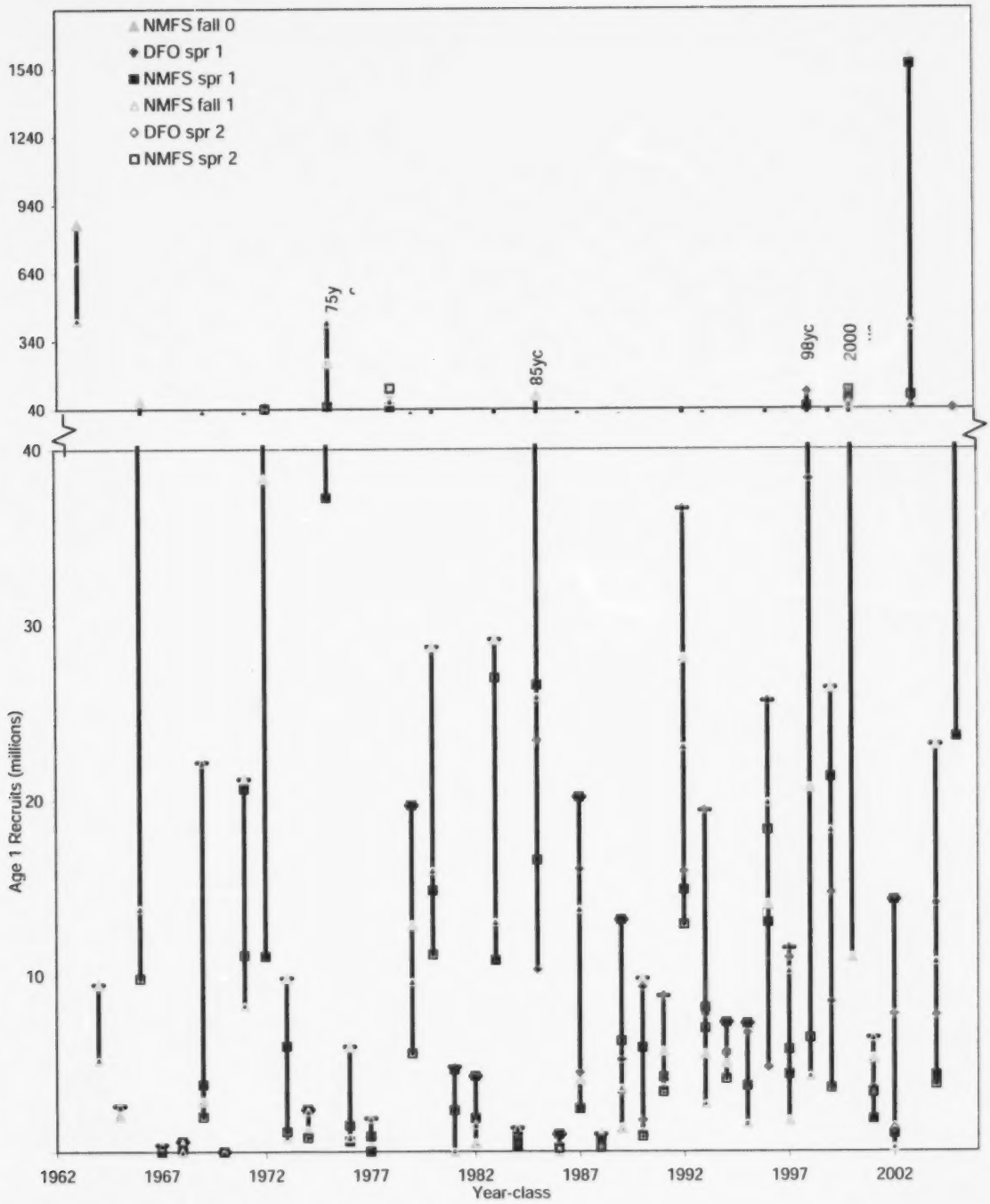

Figure 19. Year-class abundance for ages 0 and 1 from the NMFS fall survey and ages 1 and 2 from the NMFS spring and DFO research surveys (scaled by calibration constants, Table 16) for EGB haddock during 1963-2006.

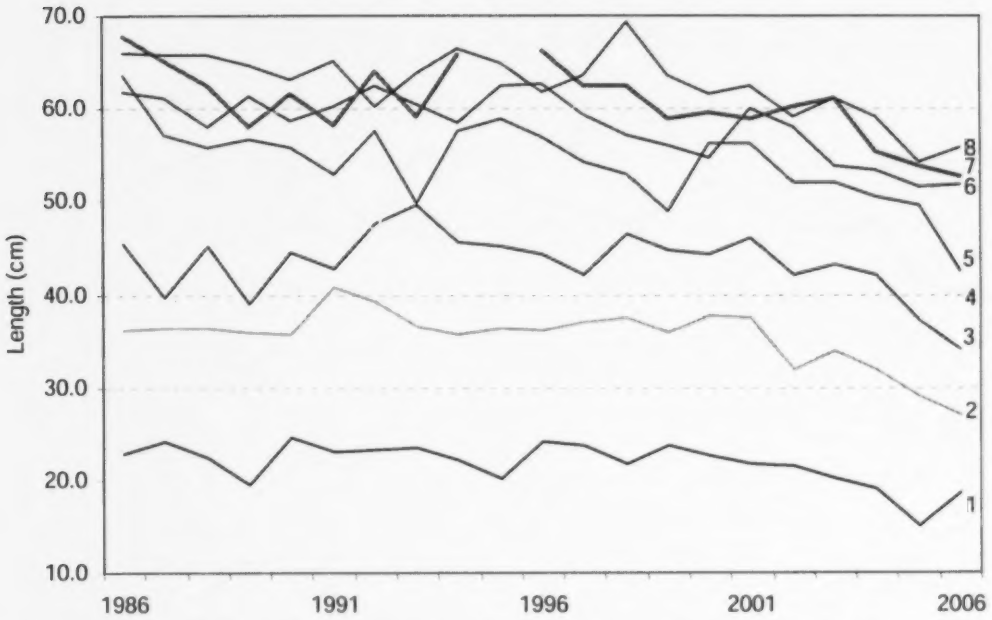

Figure 20. Length at age for EGB haddock derived from DFO surveys during 1986-2006.

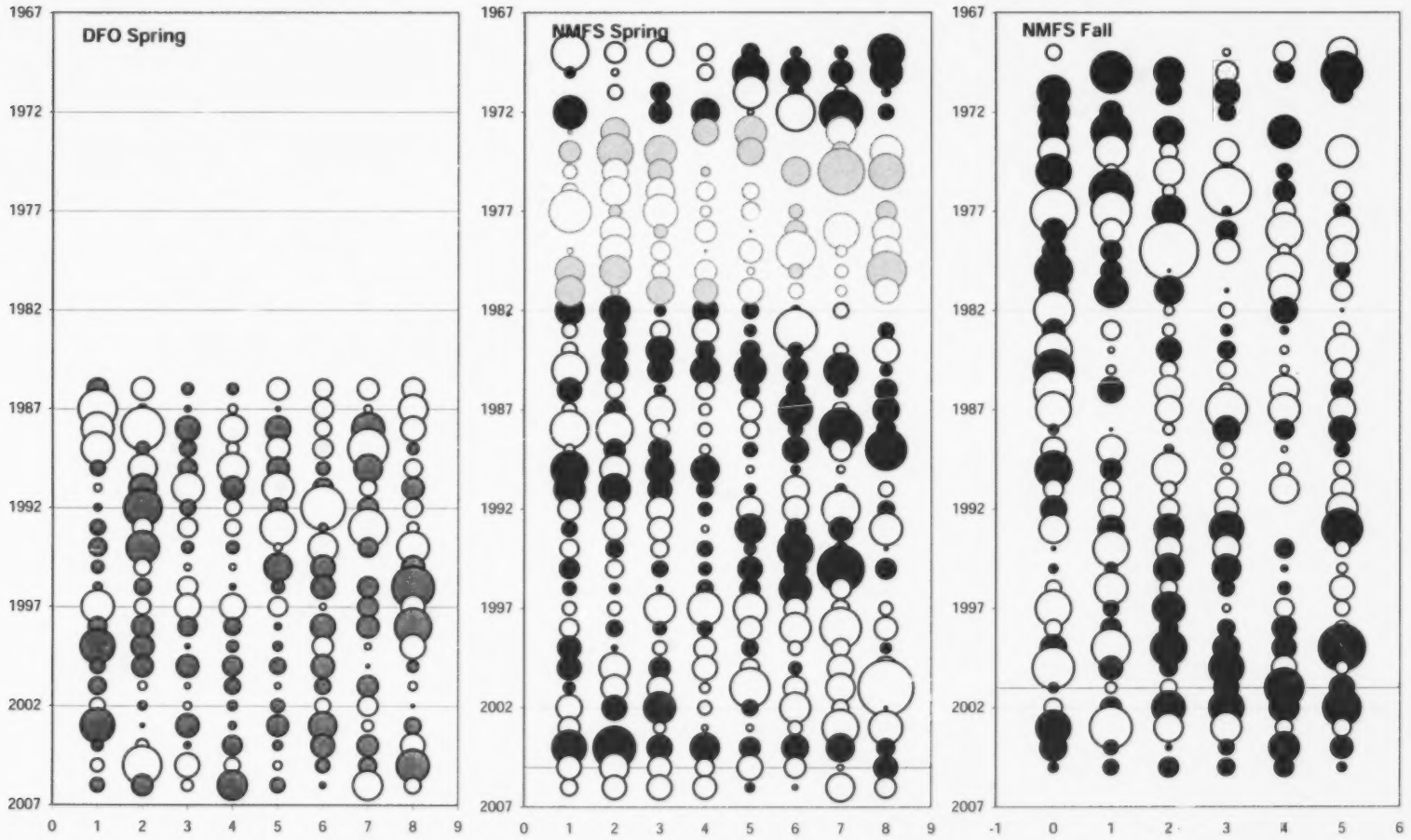

Figure 21. Residuals by year and age group for research survey indices during 1969-2006 for EGB haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

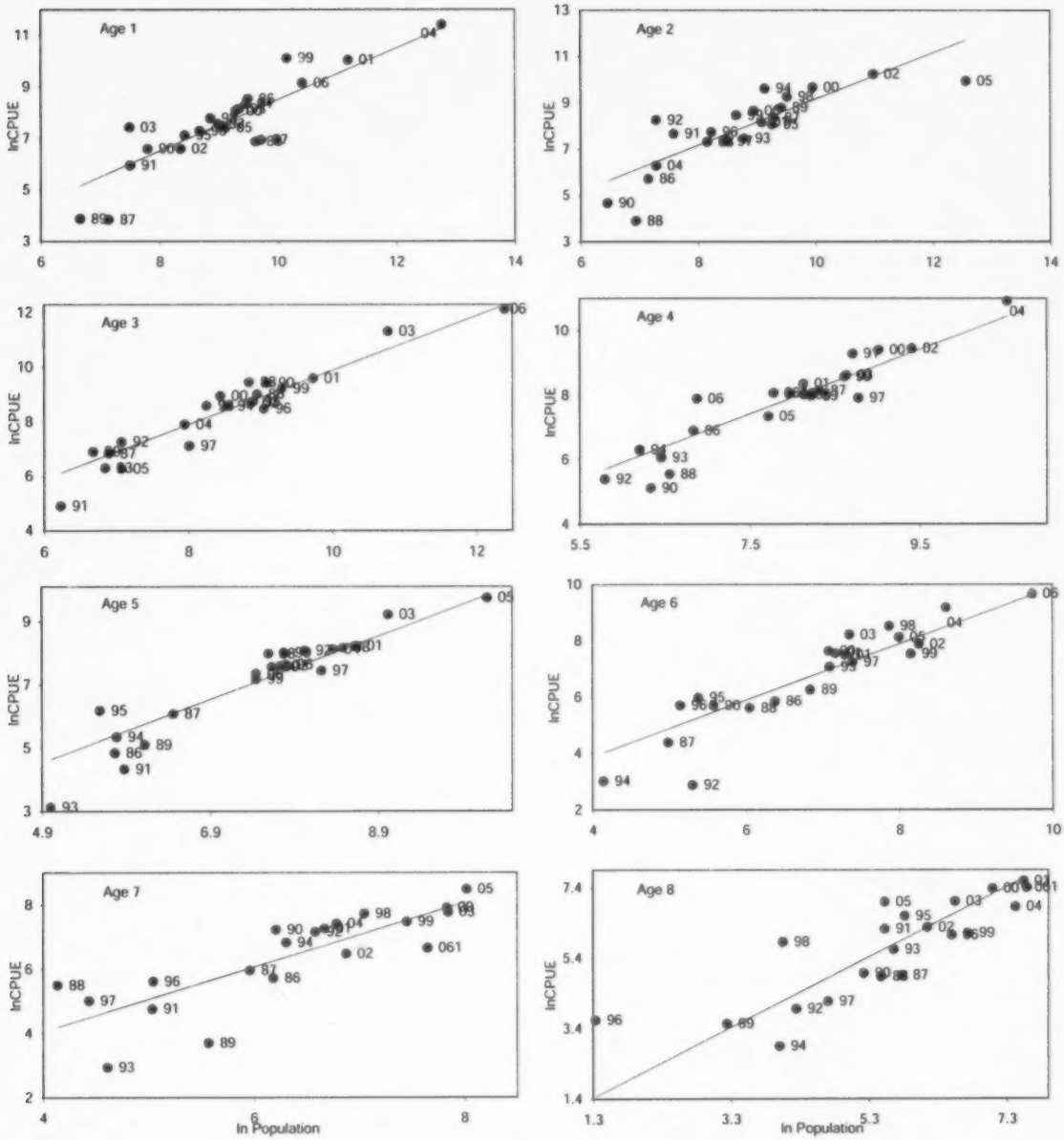

Figure 22. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **DFO** survey during 1986-2006.

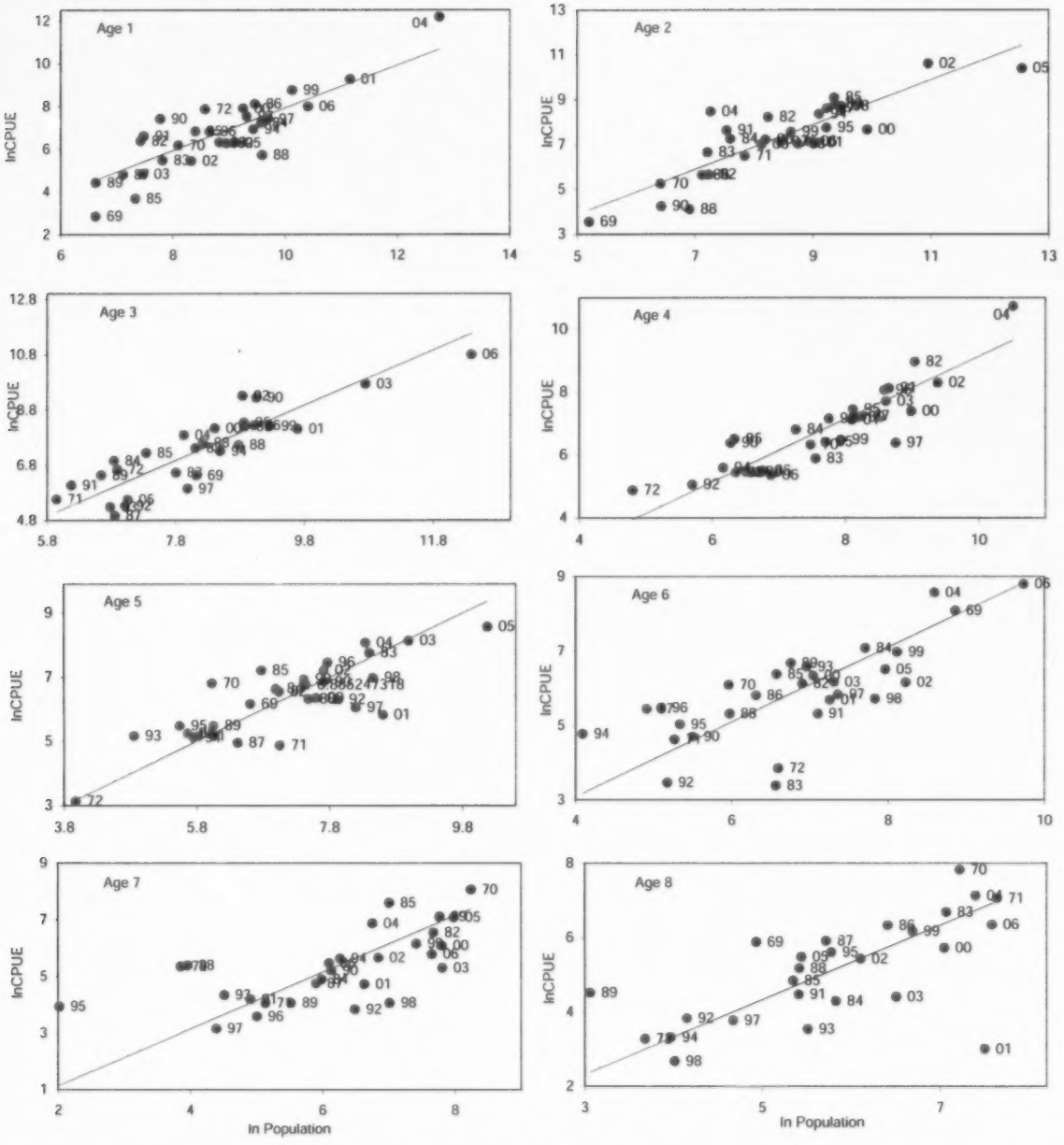

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS spring** survey with a Yankee 36 net during 1969-1972 and 1982-2006.

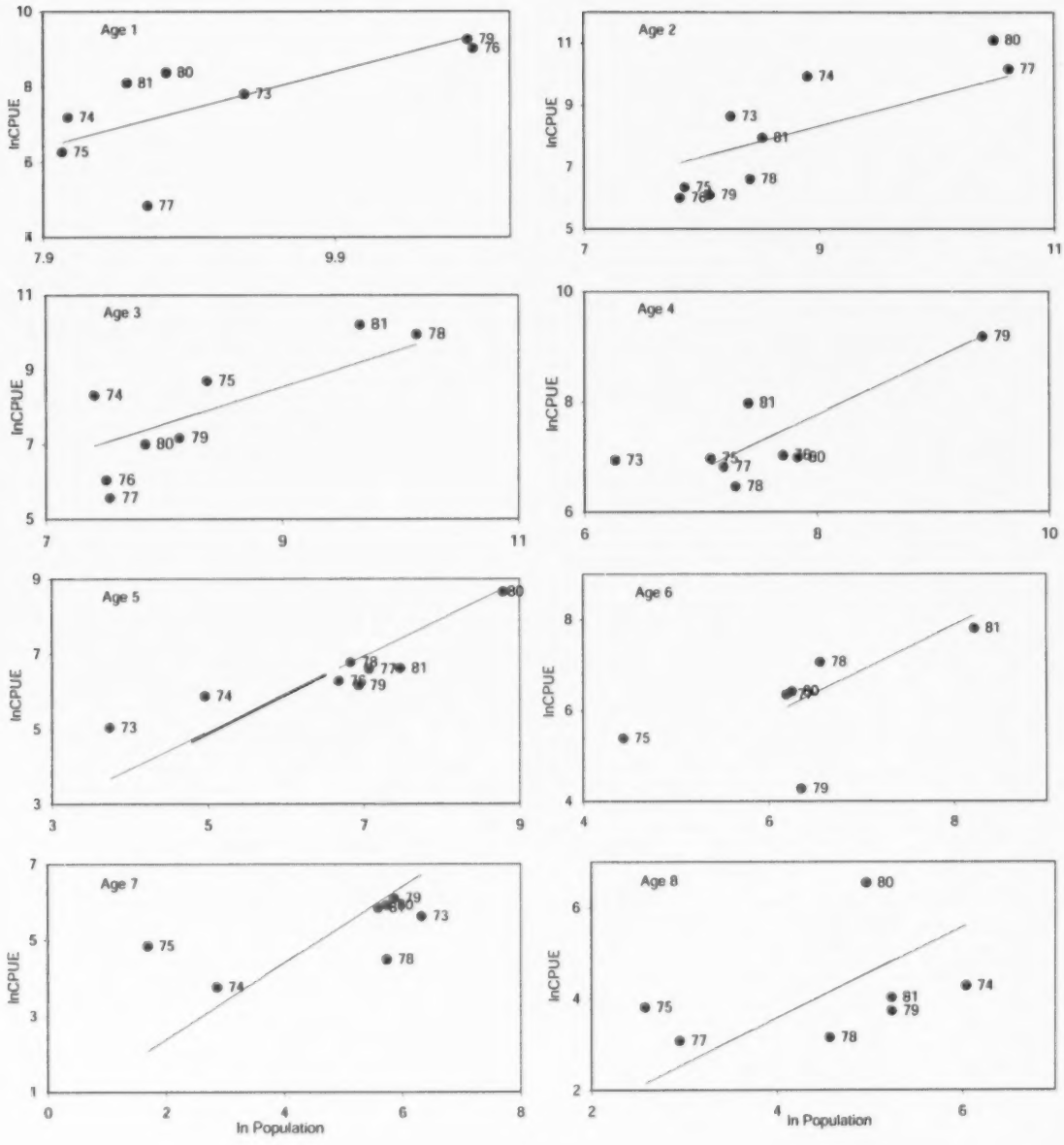

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS spring** survey with a Yankee 41 net during 1973-1981.

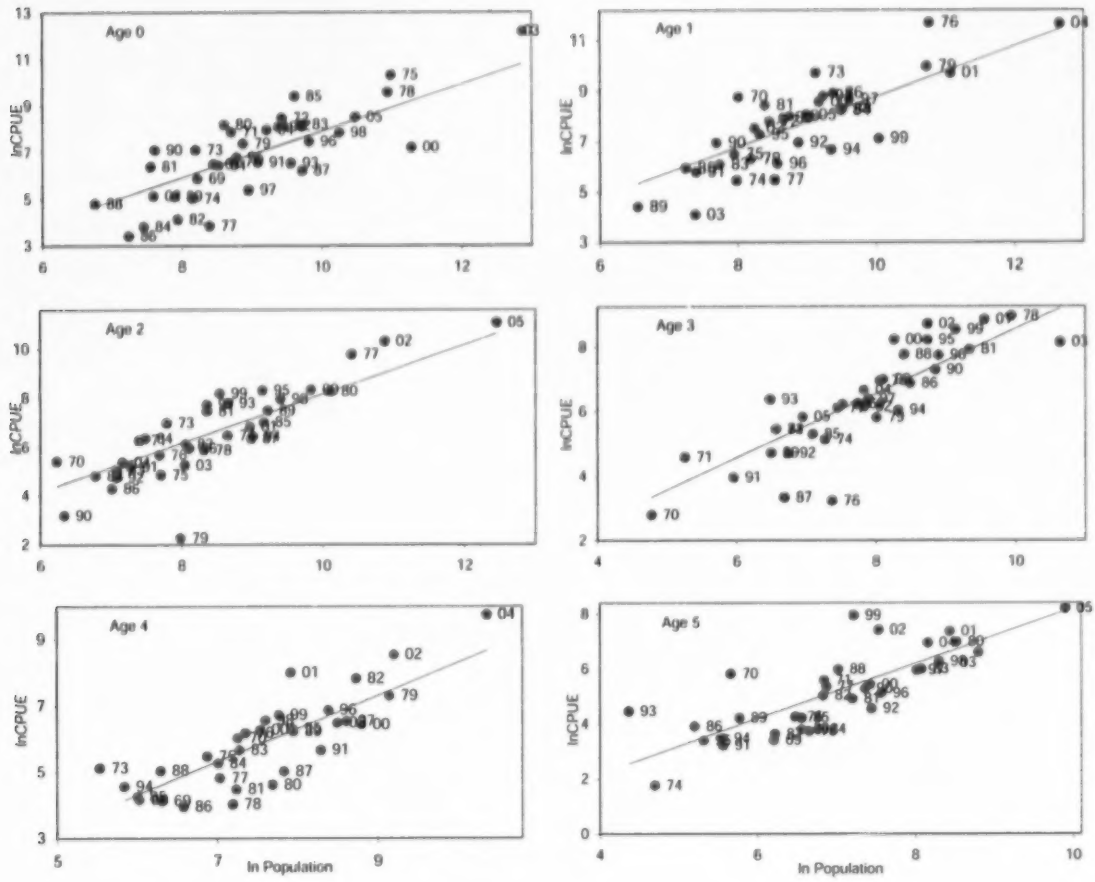

Figure 25. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for EGB haddock from the **NMFS fall** survey 1969-2005.

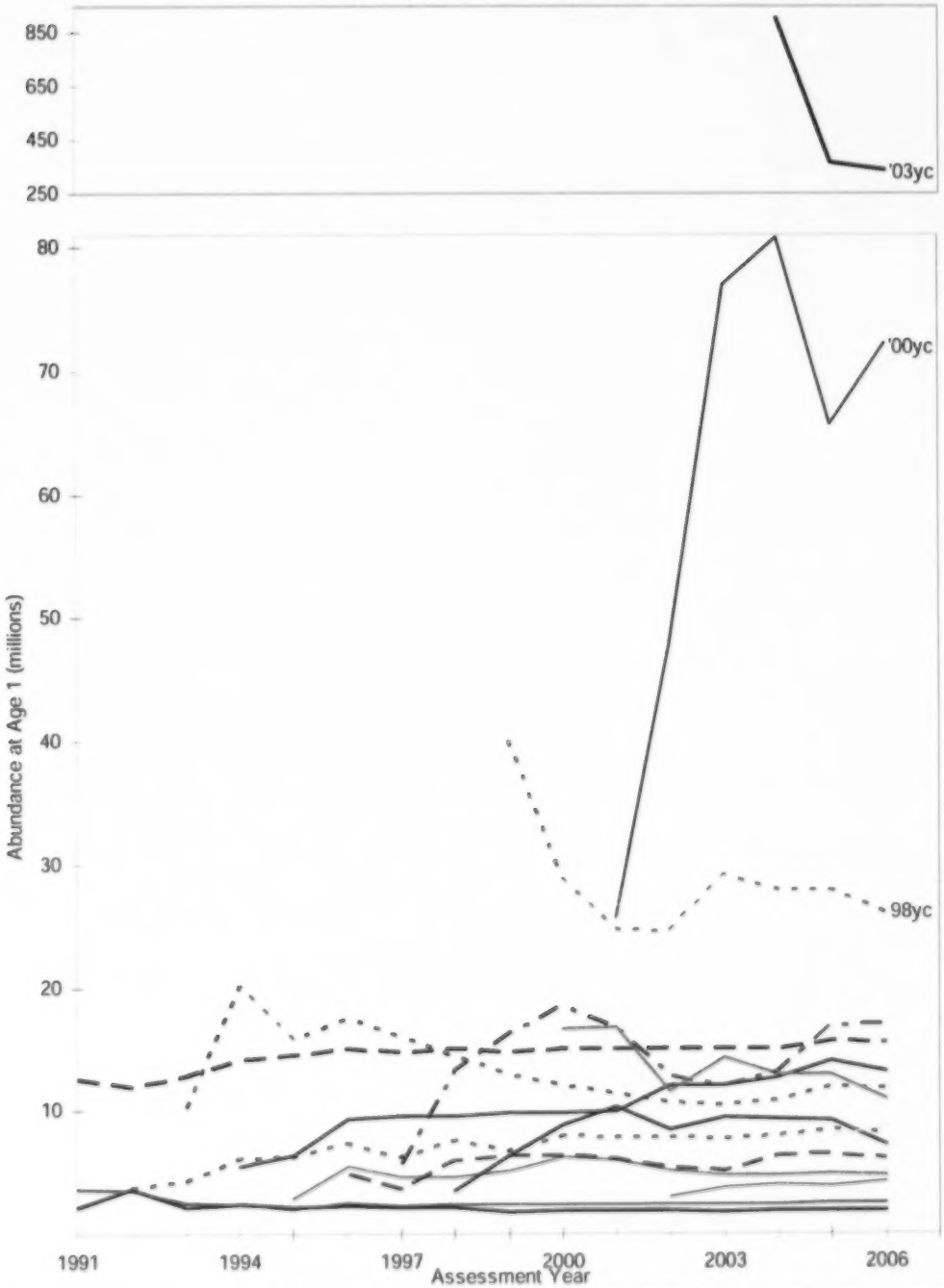

Figure 26. Retrospective estimates of EGB haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

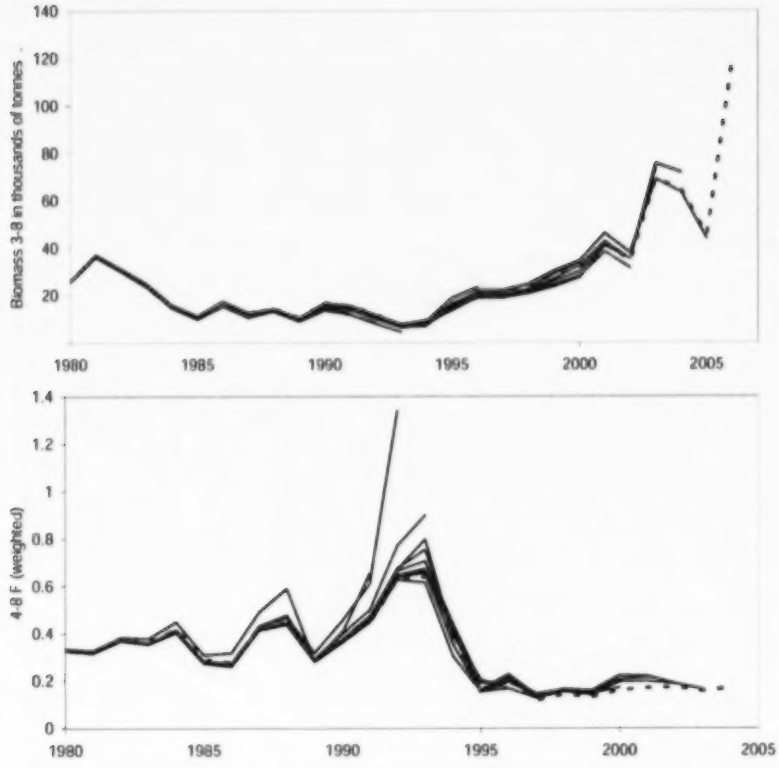

Figure 27. Retrospective estimates from VPA of EGB haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

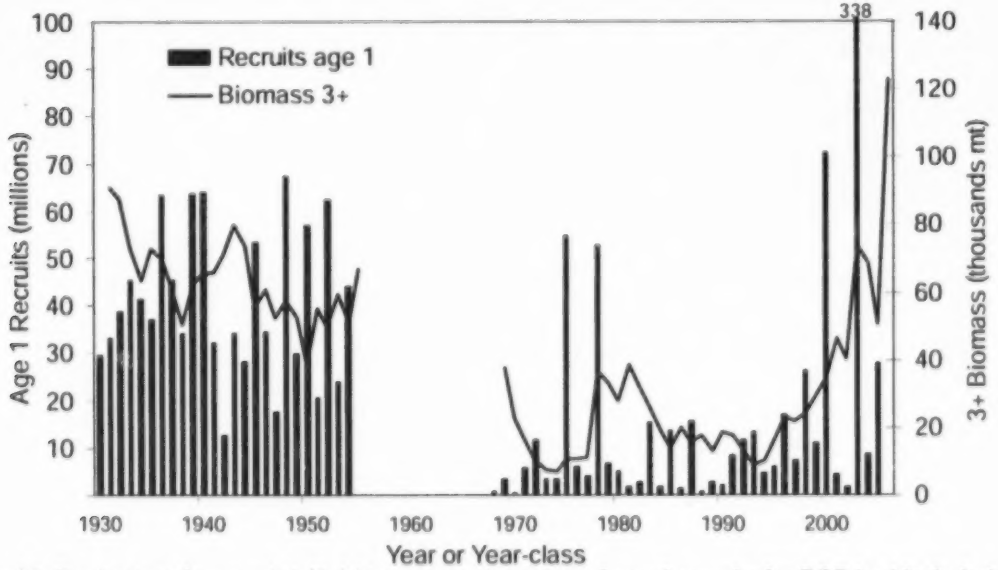

Figure 28. Beginning of year adult (3+) biomass and number of age 1 recruits for EGB haddock during 1931-1955 and 1969-2006.

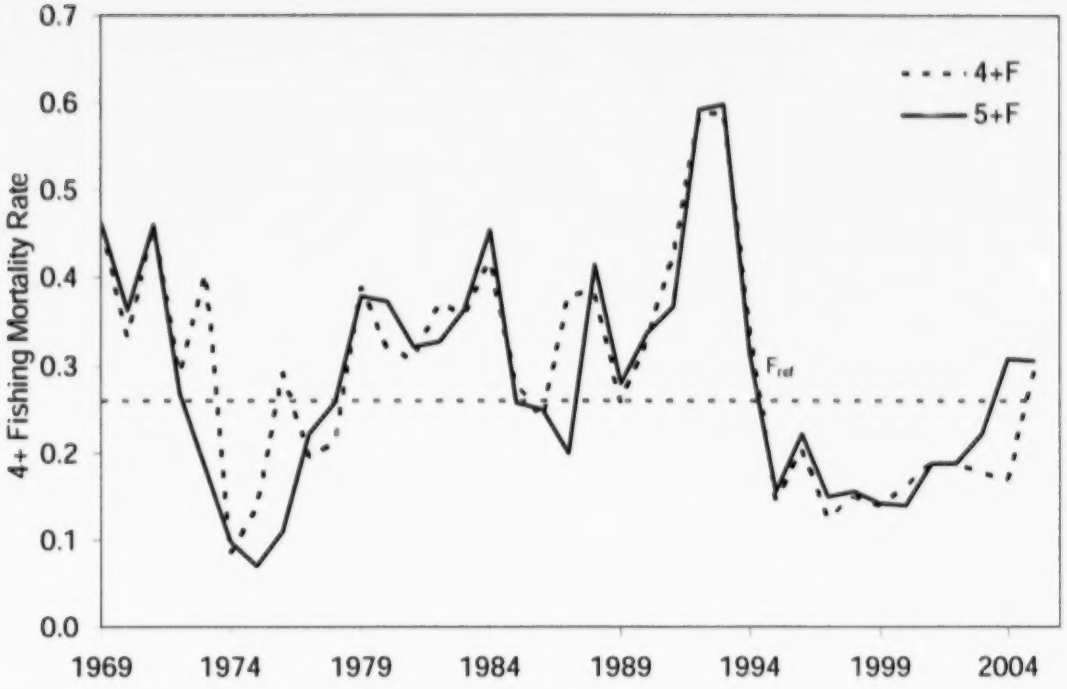

Figure 29. Fishing mortality rate for EGB haddock ages 4+ and 5+ during 1969-2005 and the fishing mortality threshold reference established at F_{ref} = 0.26.

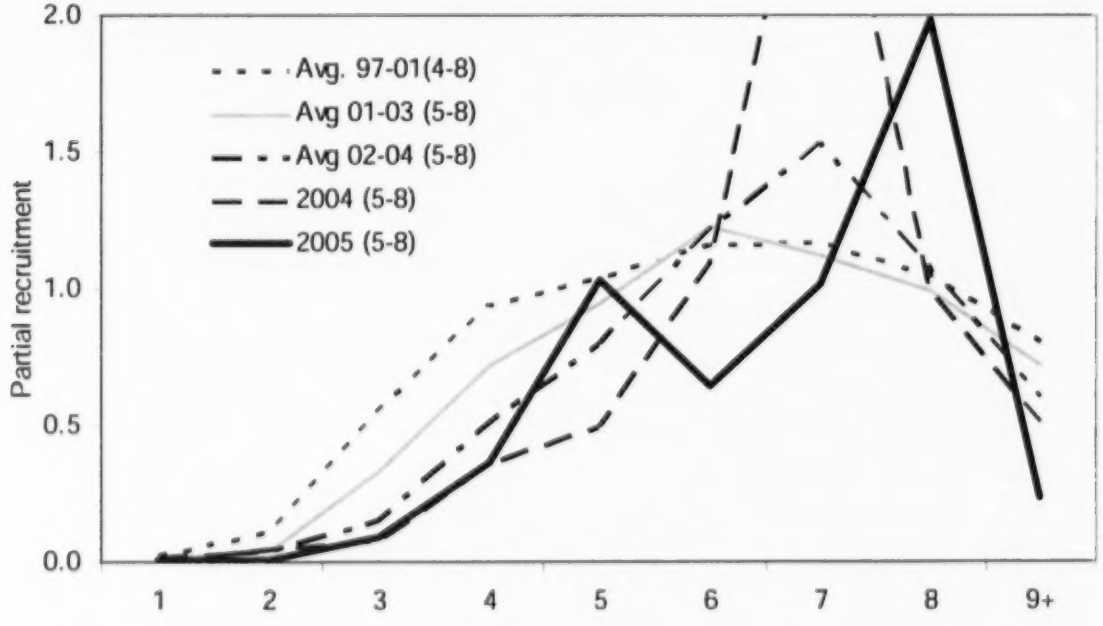

Figure 30. Average partial recruitment of EGB haddock for 3 time periods compared to the years 2004 and 2005.

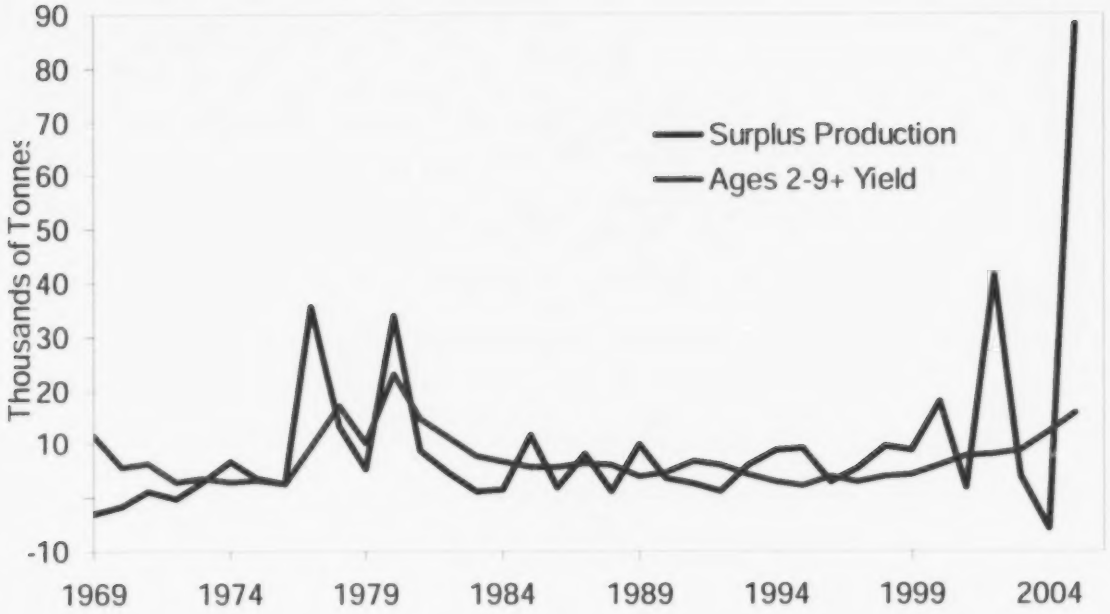

Figure 31. Surplus production of EGB haddock available to the commercial fishery compared to the harvested yield during 1969-2005.

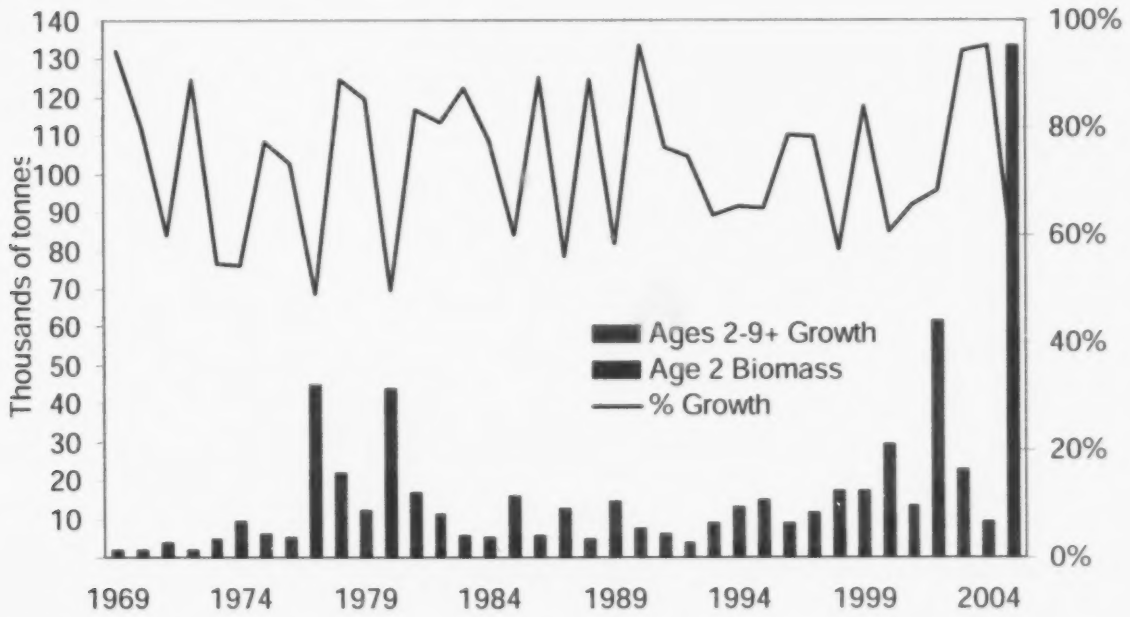

Figure 32. Amount of productivity attributible to growth (ages 2 to 9+) of EGB haddock and the amount contributed by recruitment (age 2) during 1969-2005.

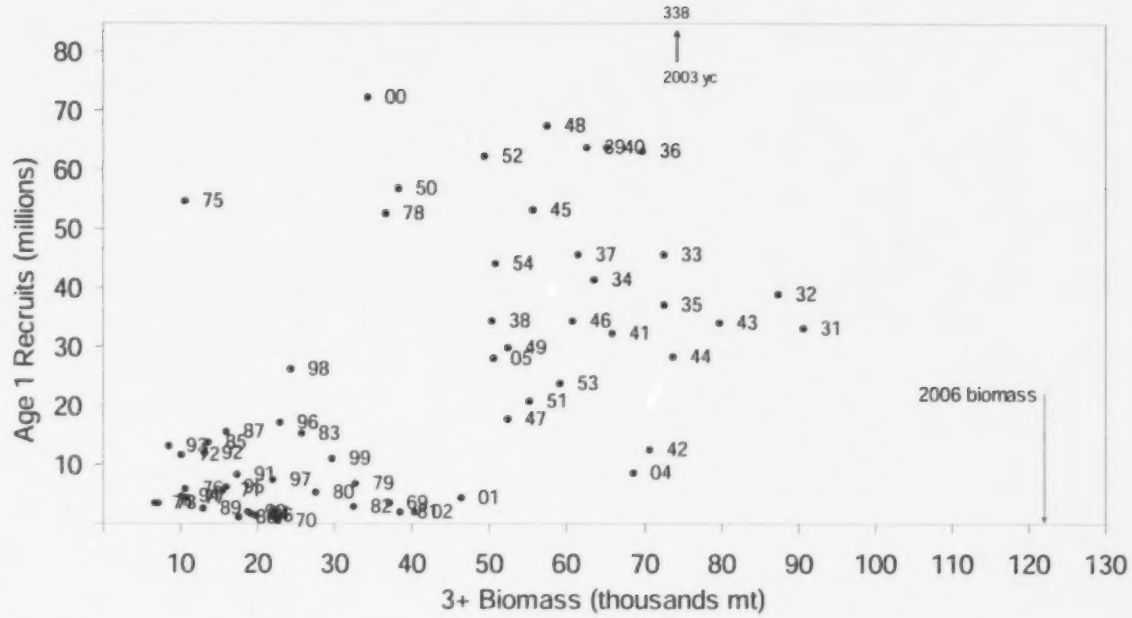

Figure 33. Relationship between EGB adult (ages 3+) haddock biomass and recruits at age during 1931-1955 and during 1969-2005.

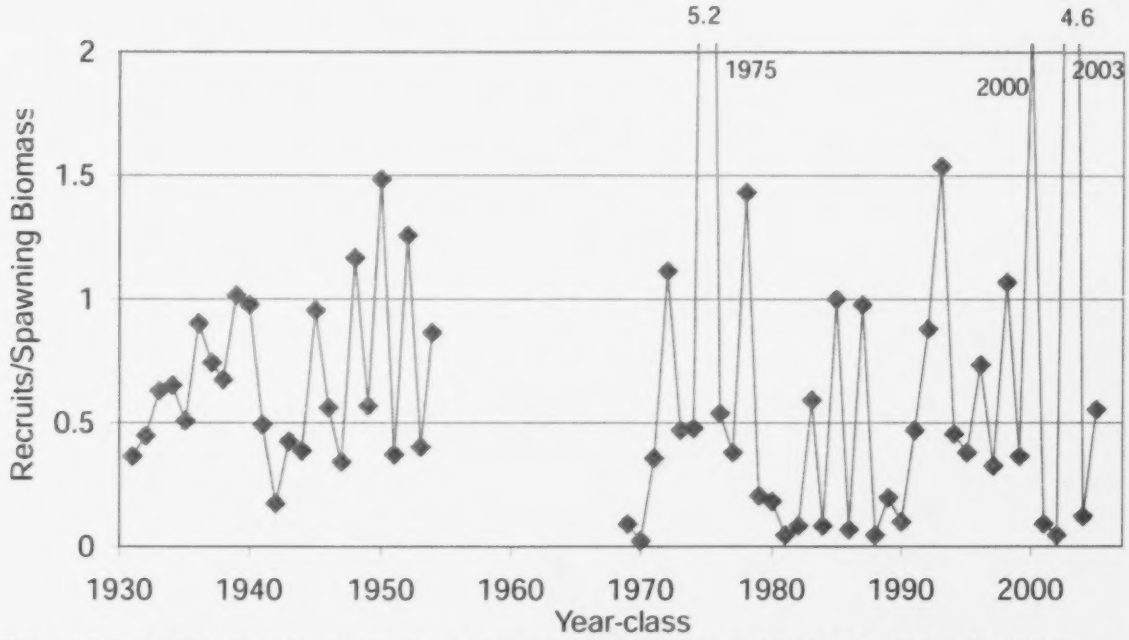

Figure 34. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for EGB haddock during 1931-1955 and during 1969-2005.

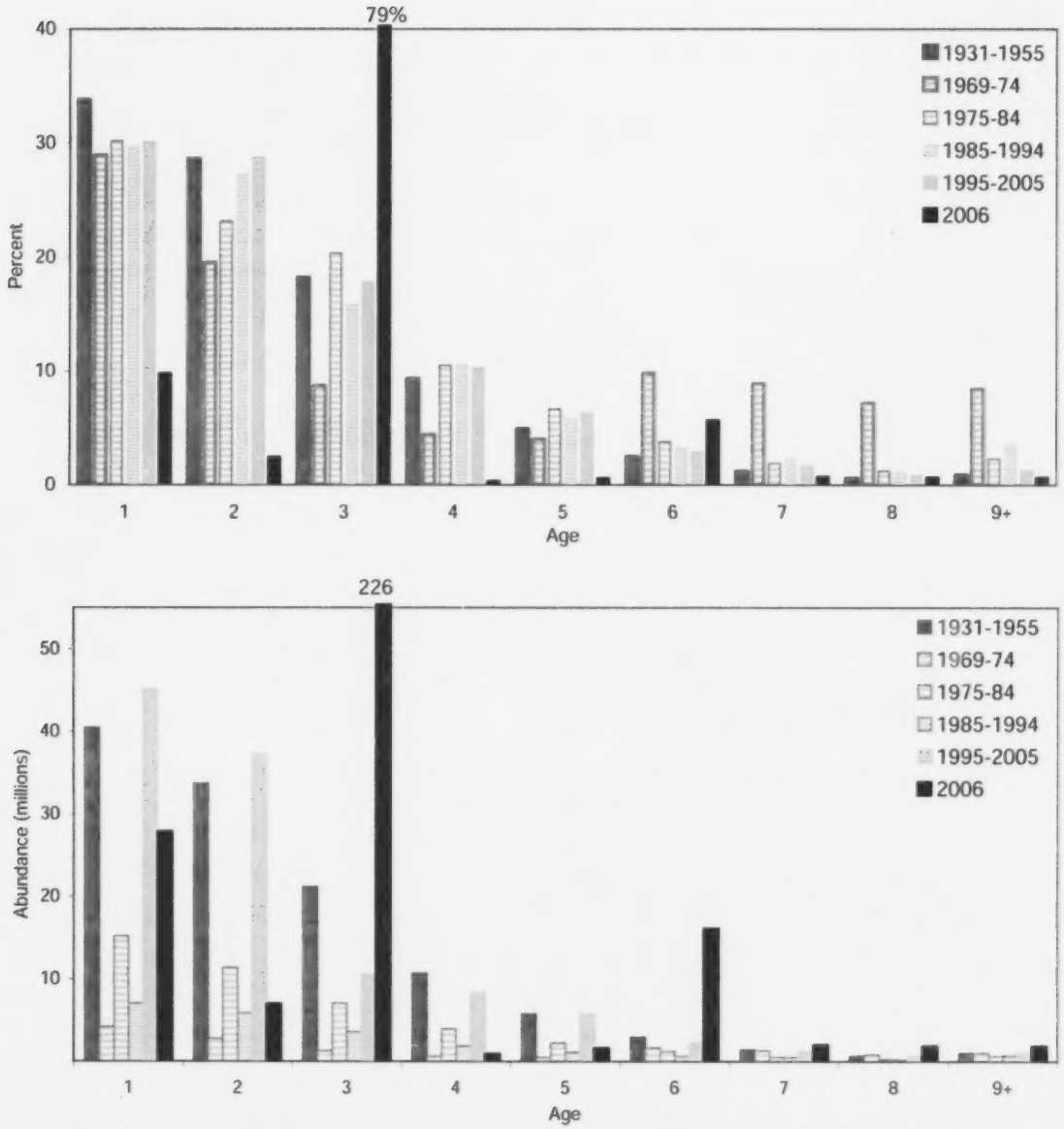

Figure 35. The age composition and absolute abundance at age of the EGB haddock population in 2006 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2005.

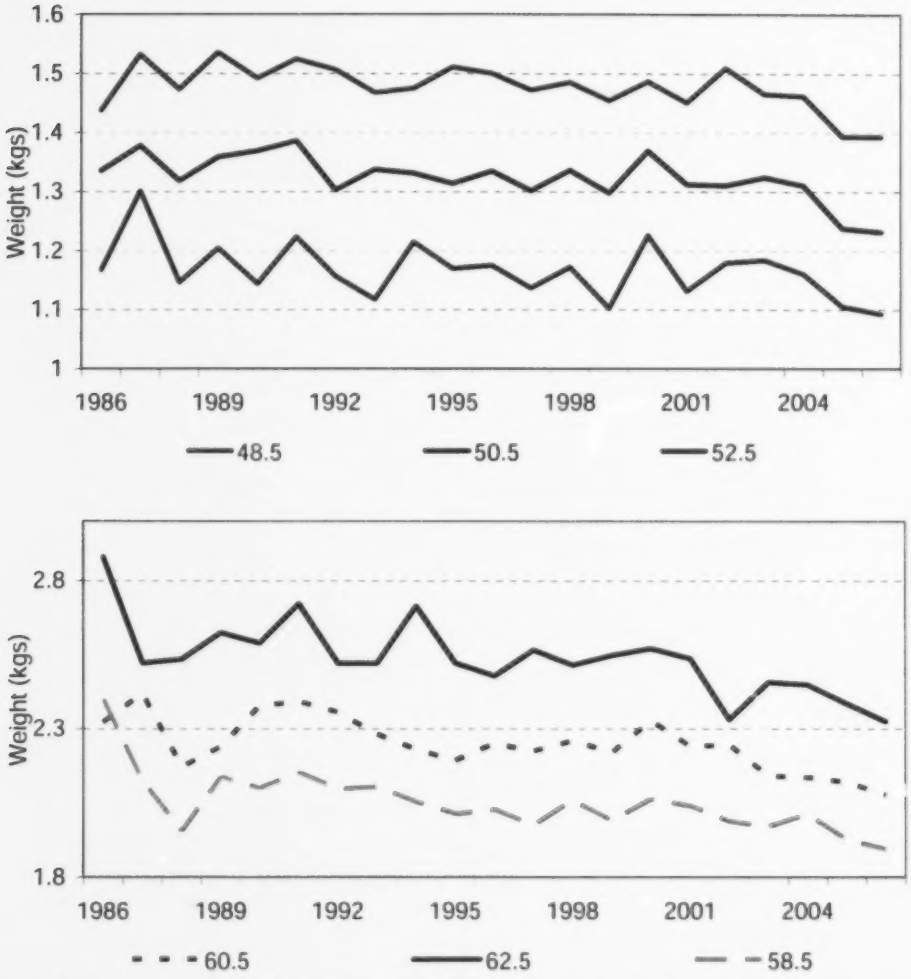

Figure 36. DFO survey weights at lengths for EGB haddock for six 2 cm length groupings during 1986-2006.

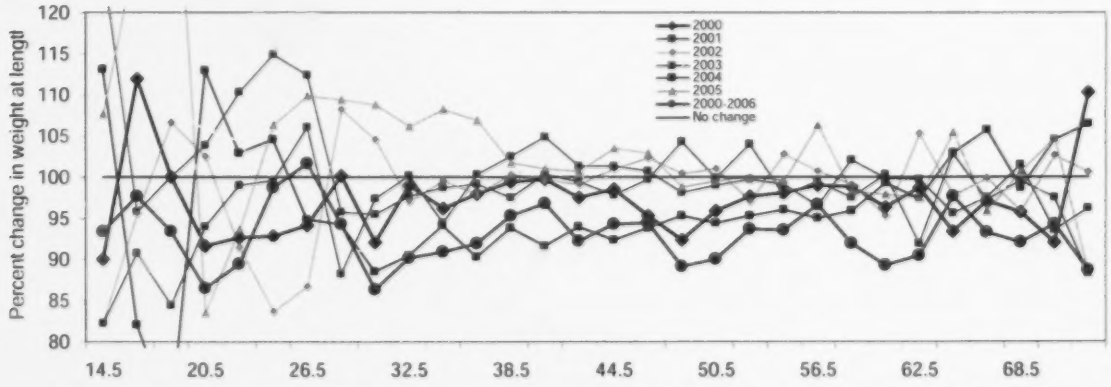

Figure 37. Percent change in DFO survey weight at length for EGB haddock during 2000, 2001, 2002 2003, 2004, 2005 and from 2000 to 2006.

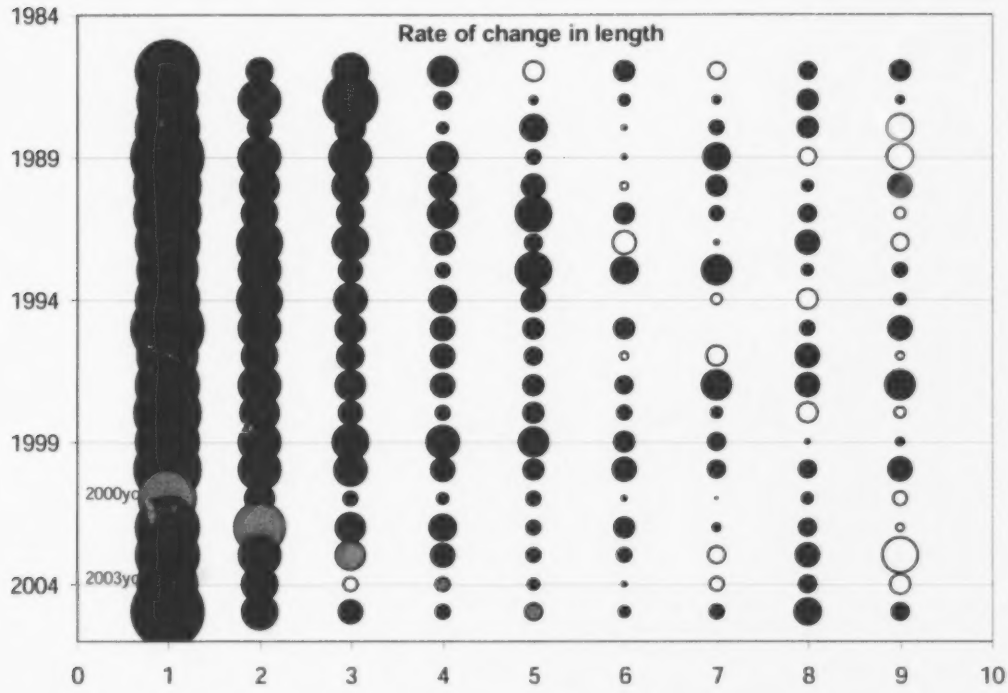

Figure 38. Rate of change in length at age for EGB haddock derived from DFO surveys during 1986-2005. Filled circles indicate a positive change and unfilled indicate a negative change. Shading used to highlight recent 2000 and 2003 year classes.

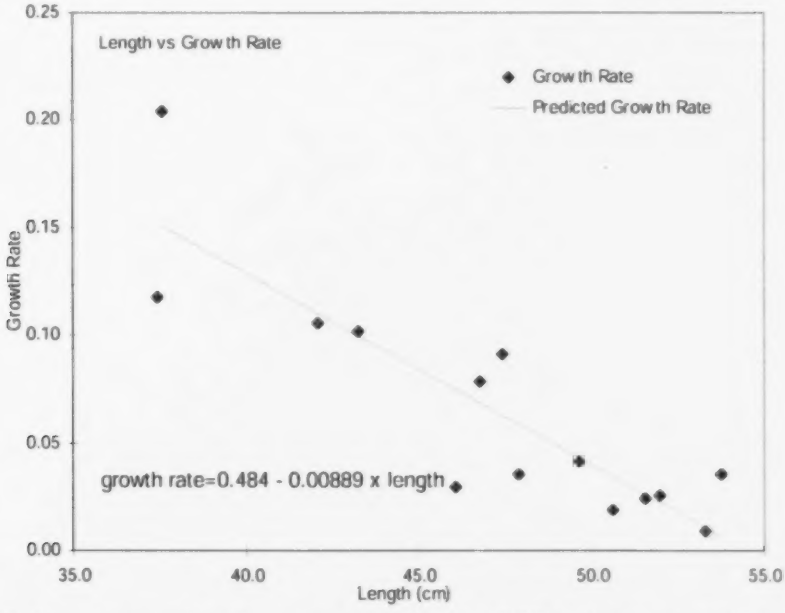

Figure 39. Relationship between length and growth rate derived for EGB haddock using observed growth increments from the 1998, 1999 and 2000 year classes.

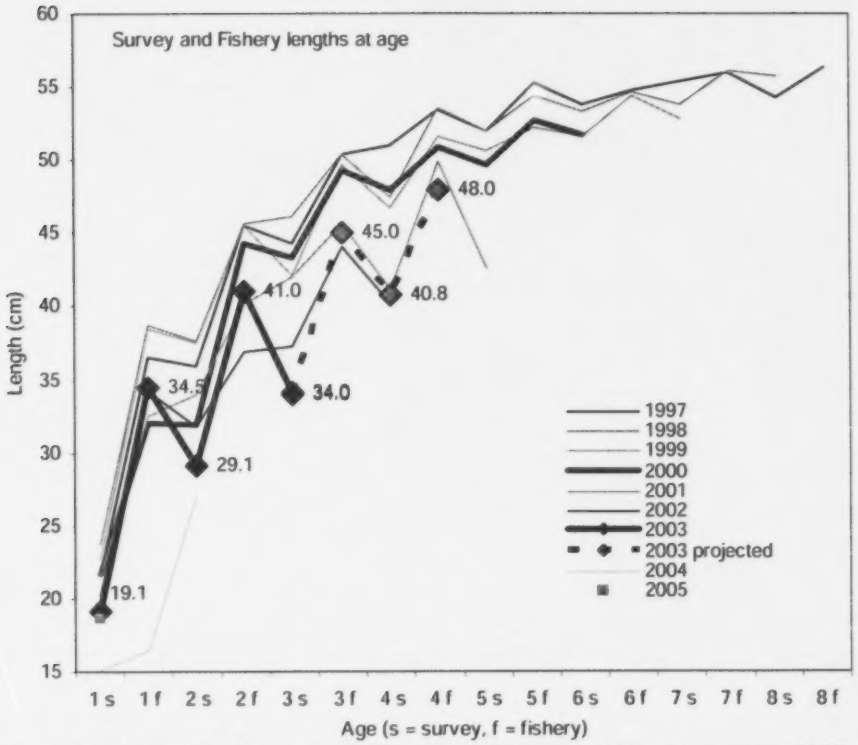

Figure 40. Average population weights at age and average fishery weights at age of the 1997 to 2005 year classes of EGB haddock as observed from the DFO survey. Population and fishery weights for the 2003 year class were estimated from adjacent year classes. Predicted lengths that were used in the risk assessment are indicated by ◆.

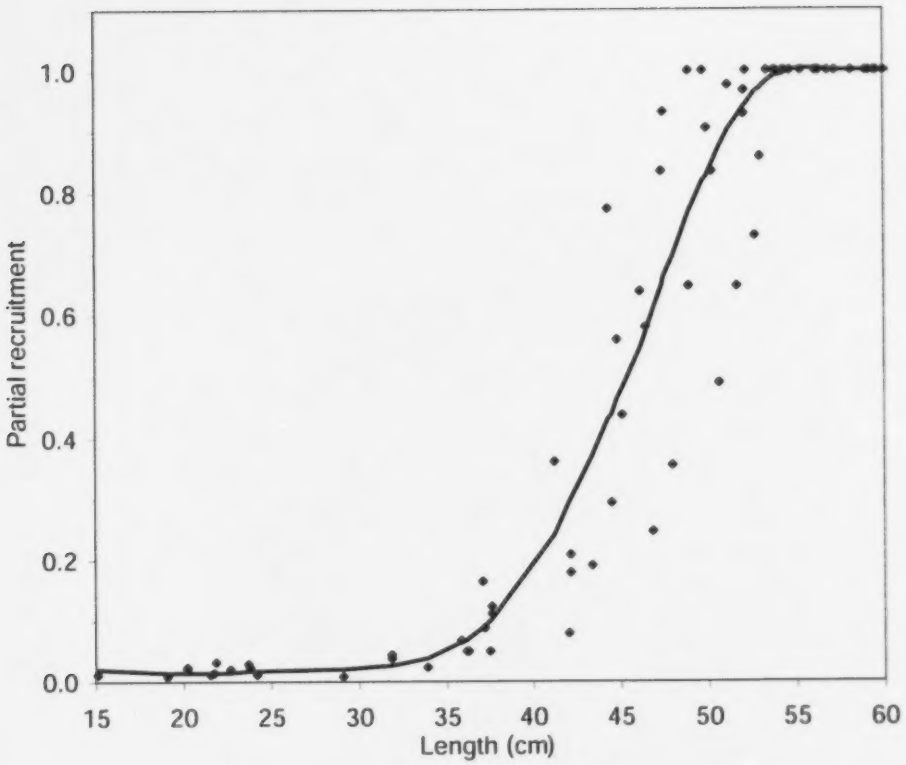

Figure 41. Partial recruitment pattern by length observed for EGB haddock in 2003 to 2005. A smoothed line was fitted to the data using a loess algorithm (Cleveland 1979).

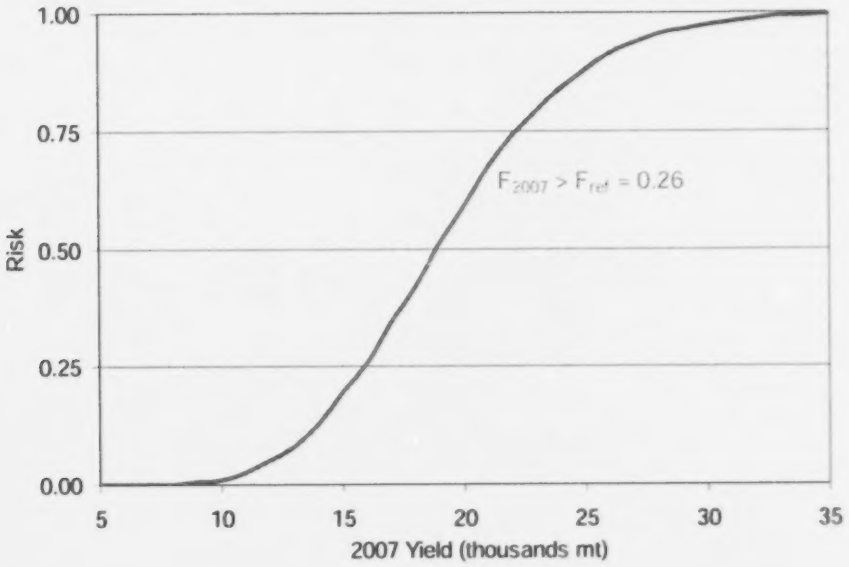

Figure 42. Risk of 2007 fishing mortality exceeding F_{ref} = 0.26 for EGB haddock for increasing catch quotas.